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MODEL FOR ESTIMATING LIFE-CYCLE COSTS ASSOCIATED WITH NOISE-INDUCED HEARING LOSS

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This report documents the development of a method for estimating the total economic costs of exposing sailors to high level, steady-state occupational noise. The costs accrue from inclusion of the sailors in the Navy hearing conservation program (HCP) and as a result of noise induced hearing loss (NIHL) sustained by the sailor. Calculation of associated economic costs requires a number of estimates and assumptions, which are provided by military audiologists and other practitioners in the Army, Navy and Department of Veteran Affairs (VA). Based on 2004 values, Navy hearing conservation program costs were determined to be $91.25 for an annual audiometric test plus $12.21 for program overhead per sailor, or more if an apparent hearing loss was detected. Specialty referrals and hearing aids for active duty sailors cost an average of $440.03 per sailor annually for this population. The medical and compensation costs of the VA system were more difficult to capture in a simple model. A number of simplifying assumptions were

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made for the VA portion. Additional mining of Navy medical and VA databases is required to develop a refined model. A numerical example is provided to illustrate application of the model. The annual economic cost to the U.S. Treasury of noise exposure for one sailor working in an ambient of 95 dBA as a specially trained machinist's mate on an aircraft carrier is $1,117.49. For the force of about 2,300 of these sailors so exposed in the fleet the cost would be $2,570,227 per year.

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EXECUTIVE SUMMARY

In the acquisition of military systems, the total life-cycle costs associated with the system, including personnel, can be included in trade-off decisions. Currently, the cash outlays by the government for noise-induced hearing loss (NIHL) caused to service personnel by loud systems and spaces are un-accounted for in estimates of life-cycle costs. A companion report demonstrated that a NIHL prediction algorithm from the American National Standards Institute (ANSI S3.44) could be modified to quantitatively apply to a single population of U.S. Navy sailors (a subset of machinist mates aboard aircraft carriers). This Report develops an algorithm for estimating the Navy and Veterans Affairs outlays for the monitoring, medical and compensation costs of the predicted NIHL in this population. A numerical example of the algorithm operation was included.

Using cost values applicable to 2005, the modified ANSI predictions of noise and aging hearing losses were tracked yearly through the specific noise exposures of a 20 yr career and 77 yr life expectancy for this group. About 2/3 were predicted to show a hearing loss while in the Navy. Navy Hearing Conservation Program costs were $103 annually per sailor (including overhead). Costs of additional audiometric study and hearing aids while still in the Navy were about $440 annually, once the sailor needed hearing aids. Re-training replacements for people with disqualifying HL would be about $1,378 (although in current practice, it seems most disqualifications receive a waiver to continue on the job). Current VA medical and compensation standards are discussed in some detail, then applied to this population. VA medical costs past Navy retirement average $10,616, and compensation for profound hearing loss in later years is $901. Tinnitus is not covered by the ANSI prediction, but can be included at current prevalence rates (+70% to NIHL costs). Each machinist mate in this aircraft carrier machinery room is conservatively expected, on average, to be responsible for about $13,409 of government outlays for NIHL over his lifetime. With other plausible assumptions, the cost can exceed $22,000 per sailor. Recommendations are presented to refine assumptions in the cost analysis.

ADMINISTRATIVE INFORMATION

This work was conducted under NSMRL Work Unit(s) 50518, entitled: Life Cycle Cost Evaluation Tool for Weapons System Noise Exposure. The views expressed in this article/report are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the United States Government. This Technical Report was approved on 10 January 2007, and designated as NSMRL/50518/TR--2007-1248.

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TABLE OF CONTENT

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1. ABSTRACT

This report documents the development of a method for estimating the total economic costs of exposing sailors to high level, steady-state occupational noise. The costs accrue from inclusion of the sailors in the Navy hearing conservation program (HCP) and as a result of noise induced hearing loss (NIHL) sustained by the sailor. Calculation of associated economic costs requires a number of estimates and assumptions, which are provided by military audiologists and other practitioners in the Army, Navy and Department of Veteran Affairs (VA). Based on 2004 values, Navy hearing conservation program costs were determined to be $91.25 for an annual audiometric test plus $12.21 for program overhead per sailor, or more if an apparent hearing loss was detected. Specialty referrals and hearing aids for active duty sailors cost an average of $440.03 per sailor annually for this population. The medical and compensation costs of the VA system were more difficult to capture in a simple model. A number of simplifying assumptions were made for the VA portion. Additional mining of Navy medical and VA databases is required to develop a refined model. A numerical example is provided to illustrate application of the model. The annual economic cost to the U.S. Treasury of noise exposure for one sailor working in an ambient of 95 dBA as a specially trained machinist's mate on an aircraft carrier is $1,117.49. For the force of about 2,300 of these sailors so exposed in the fleet the cost would be $2,570,227 per year.

2. BACKGROUND

a. The U.S. military exposes some of its personnel to hazardous levels of noise. Despite the use of engineering controls and the establishment of HCP, thousands of service people suffer permanent NIHL. Not only do these losses affect military performance and individual quality of life, but they also incur specific monetary outlays by the U.S. government. At this time, system-acquisition planning does not account for the costs of NIHL in engineering life-cycle trade-off decisions. The present project is an initial attempt to (1) relate the NIHL of a specific occupational group in the U.S. Navy to the source of their greatest noise exposure, and (2) account for the associated economic costs of the NIHL incurred by this population.

b. This report is the second of two.

(1) The first report (reference 2) describes the adjustment of the ANSI standard S3.44-1996 predictive algorithm (reference 15) in an effort to relate the NIHL of a specific occupational group in the U.S. Navy to the source of their greatest noise exposure. The ANSI S3.44-1996 provides an algorithm to calculate the predicted NIHL and age-related hearing losses of a population, given certain population and noise-exposure parameters. This algorithm is limited in its applicability in several respects and did not accurately predict the NIHL for the target Navy population. However, an adjustment to the noise level parameter of -5 dBA produced good agreement between ANSI S3.44 predictions and observed Navy audiometric data.

(2) This report outlines the development of a model for estimating the total economic cost of exposing sailors to high shipboard steady-state noise levels. It uses reference 2 to predict the hearing threshold levels and their probabilities.

3. COST MODEL DEVELOPMENT APPROACH

a. The first step is to identify all the processes and procedures relating to noise exposure which incur economic costs. Since all such costs are personnel-related, it is convenient to enumerate these processes according to the progression of the noise-exposed sailor's career. Table 3.1 shows the major milestones in a career progression and their audiologic significance.

Table 3.1. Major Milestones in a Noise-Exposed Sailor's Career and Their Audiologic Significance

Sailor's career milestone	**Audiologic and cost significance**	**Is cost due to noise? Payer**
Enlists in Navy	Must pass entry hearing test, results in a screened population, baseline audiogram established	No
Basic training and advanced training	Assume not noise exposed	No
Assigned to high noise occupation	Annual monitoring audiometry, noise exposure documented on permanent medical record	Yes, Navy
Sustains significant threshold shift (STS), a permanent hearing loss	Retest, reset baseline audiogram and audiologist referral	Yes, Navy
Sustains hearing loss	Referral for hearing aid exam	Yes, Navy
If reassigned due to hearing loss, leaves occupation	Navy incurs cost for training replacement personnel, medical costs	Yes, Navy
If normal progression, eventually leaves subject occupation	Leaves hearing conservation program, no separation audiogram	No
Retires or non-reenlists, enters Department of Veterans Affairs (VA) purview	Navy separation audiogram	No, Navy
VA compensation and pension exam	For hearing impairment	Yes, VA
VA medical benefits	Hearing aids, others	Yes, VA
VA compensation benefits	Disability compensation, can be primary or secondary	Yes, VA
Dies	Noise exposure-related costs cease	No

b. Generally, a cost algorithm is comprised of two elements: the cost incurred in executing a specific process or procedure, and the probabilities associated with triggering that process or procedure.

(1) Cost for procedures are developed for each of the career milestones identified as incurring economic costs. The primary sources of procedural information are practitioners in the Navy and VA as well as official correspondence and official web pages. The practitioners contributing to this effort are listed in appendix B.

(2) The probabilities are either calculated from the algorithm for HLs, estimates from practitioners, or derived from data in existing databases.

c. A two-level effort is used for the cost algorithm: baseline, and refined.

(1) This initial report covers the baseline model for the cost algorithm. The baseline model addresses all the major contributors to NIHL-related costs but includes simplifying assumptions and practitioner-established estimates of key parameters and some probabilities.

(2) The refined model is expected to be developed during follow-on efforts. The refined model is discussed only to the extent of identifying the general approach to future refinement and validation of the various assumptions and practitioner generated estimates. Appendix C contains a compilation of items requiring further validation for the refined model and the approach for the validation.

(3) Running the baseline model will also enable defining the sensitivity of costs to the possible parameters.

d. The cost calculation uses a one year computation cycle for active duty Navy time. This cycle corresponds to the audiometric test interval used by the Navy hearing conservation program for most enrollees. A one year cycle is also used for VA costs. Cost data are generally from the year 2004.

4. FUNDAMENTAL CONSIDERATIONS

a. Costs considerations.

(1) Costs attributable to each item of high-noise equipment are entirely personnel-related costs for the assigned sailors.

(2) Allocated costs always include all the variable components but require a decision on including any portion of the fixed and overhead costs. Guidance from the DoD Comptroller's office about military manpower cost rates do not include any allocation for overhead (reference 1) (e.g. the cost of installation land and buildings, utilities, personnel support, HQ staffs at all levels, and the like). Overhead costs would normally be included in economic cost models. In this case, the small number of people involved in the Navy hearing conservation program (HCP) would probably not change the actual Navy overhead expenditures. This supports not including anything other than Navy personnel costs. The personnel cost rates in reference 1 do include leave, health care, retirement, etc. Overhead costs for the VA are included and are estimated from published VA reports.

(3) The model is structured to easily accommodate both "should cost" and "actual cost" formulation. The “should cost” case covers procedures as would occur in a perfect world with no fiscal or personnel constraints. The baseline model uses the “actual cost” case and covers

procedures as actually occurring in the field. For example, not all sailors in the HCP show up for annual audiometric tests. The “should cost” expense for such testing would be higher than the “actual cost” expense.

b. The following are assumed as given inputs to the cost model:

(1) Staffing scheme including number of sailors by Navy enlisted classification (NEC) or specialty, the sailor’s age at entry into the high noise occupation, and average number of years in the career field assuming that that disqualification due to acquired hearing loss does not occur.

(2) All assigned sailors’ noise exposure as 8-hr time weighted noise levels (TWAs) using a 3 dB tradeoff rate between level and time duration as recommended by ANSI S3.44. See 8b for TWA computations using both Navy and ANSI.

(3) The probability distribution of hearing levels (HL) by frequency for any noise exposure level and number of years of exposure are generated by the Navy HL algorithm (reference 2). The HL values are all permanent threshold shifts (PTS). Values of temporary threshold shift (TTS) are not generated and are not used by the model.

(4) The sailors’ medical records are complete: i.e., include entry and exit audiograms; document the inclusion of the sailors in the Navy HCP; and list the noise levels to which the sailors were exposed.

c. Use of ANSI S3.44-derived HLs.

(1) The scope of applicability of the ANSI S3.44 algorithm is limited to an 8-hr TWAs (or effective equivalent) range of 75 to 100 dB, periods of exposure of 0 to 40 years, and fractiles from 0.05 to 0.95. The model parameters are within these limits with one exception: algorithm-generated HLs for fractiles from 0.005 to .99 are used.

(2) The ANSI S3.44 algorithm appears to generate spurious values NIPTS at 2 kHz for low fractiles and low years of exposure as shown on table 4.1. This appears to be a warp since the NIPTS at 2 kHz would not normally be greater than at 3 kHz and the NIPTS at 2 kHz would not jump to 16 dB after 1 hour at 93 dBA. For computations, the 2 kHz NIPTS is always taken as the lesser of the 2 and 3 kHz values.

(3) The ANSI S3.44 algorithm can generate HTLAN values below -10 and above 110 dB. While these may be theoretically possible, audiometers cannot measure outside these limits. Since costs will be incurred based on real measurements, predicted HTLAN values above 110 dB are set equal to 110 dB. Values below -10 dB do not trigger any costs and were not adjusted.

5. NAVY HEARING CONSERVATION PROGRAM AND MEDICAL COSTS

a. Introduction. The Navy HCP costs are comprised of administrative and overhead (OH) costs and costs of hearing conservation clinic visits. Pertinent Navy medical costs relate to hearing aid (HA) clinic visits. Paragraphs 5b through 5d outline the costs for the various types of HCP clinic visits and medical procedures. Paragraph 5e discusses the associated probabilities and expected values.

b. Navy HCP overhead.

(1) All sailors assigned to noise-hazardous areas are placed in the Navy HCP. The enrollment accrues cost for the full-time Navy HCP staff and the annualized cost of fielding the Defense Occupational and Environmental Health Readiness System – Hearing Conservation (DOEHRS-HC), an automated audiometric testing system, see Table 5.1.

(2) The unit personnel costs are from DoD guidance (reference 1). Table 5.1 does not include the cost of those personnel such as occupational health nurse, safety specialist, and industrial hygienist who perform HCP functions as added, part-time duties. These personnel and positions would probably not be eliminated if there was no Navy HCP.

(3) Cost of HCP overhead attributed to each enrollee is obtained by dividing the total by the number of personnel in the Navy HCP. In 2004 the number was 350,381 including both military and civilians (reference 3) and the per enrollee cost is $12.21.

Table 5.1. Detailed AO Costs, Annual Navy HCP (Institutional)

Item	Quantity	Unit cost, $	Subtotal, $
O-5 Audiologist	1	151,966	151,966
O-4 Audiologist	4	137,459	549,836
O-3 Audiologist	10	111,461	1,114,610
O-2 Audiologist	2	87,497	174,994
GS-14/6 Program manager	1	126,026	126,026
GS-13/6 Project officer	2	106,645	213,290
GS-12/6 Project officer	8	89,680	717,440
GS-11/6 Technician	1	74,827	74,827
Annual DOEHRS-HC costs			1,113,969
		Total	4,276,958
Average annual cost for each of 350,381 (as of 2004) enrollees			12.21

Note:
1. Reference 1 directs using the “annual DoD composite rate” for budget/management studies.

2. Civilian pay is based on “rest of US” rate increased by 26.9% per reference 1.

c. Costs of HCP periodic visits.

(1) All enrollees in the HCP are subjected to periodic testing which includes audiograms, health education, and hearing protection checks. These encounters with HCP personnel are usually annual. Although there are circumstances under which the encounter could be more frequent than annual, these are rare and the baseline model uses annual visits.

(2) Annual audiometric testing is performed using the hardware and software of DOEHRS-HC. The system automates the annual testing and recordkeeping thereby documenting the progression of hearing loss, if any. The test results become part of the sailor's permanent medical record. There are provisions to include in the record the noise exposure level but the implementation will not be complete until the link to the industrial hygiene module is operational. The system also compiles results of all Navy hearing conservation audiometric testing into an audiometric data repository (DR) which contains data from approximately 1999 on.

(3) The purpose of annual audiometric testing is to identify the more susceptible individuals by identifying TTS before it becomes PTS and by monitoring the growth of hearing loss. This timely identification allows the hearing conservationist to prevent hearing loss through timely intervention.

(a) The intervention occurs whenever the patient's audiogram exhibits a verified significant threshold shifts (STS) (reference 4). The STS is defined as a change in hearing of an average of ± 10 dB at 2000, 3000 and 4000 Hz in either ear relative to the current reference audiogram. The verification requires one or two follow-up audiograms.

(b) The STS-related sequence starts with the annual audiogram which may give an indication of STS which may be real or false. Up to two follow-up audiograms are performed to resolve the STS indication. If the indication is not resolved after the second follow-up audiogram then the indicated STS is accepted as real and the baseline audiogram is reset.

(c) The annual audiometric testing and STS evaluation is a convenient computational point for also evaluating hearing aid referrals and for verifying that the sailor meets minimum hearing standards for the rating, if any. The premise is that the noise-induced hearing loss may grow over time until the sailor fails to meet the criteria and is forced to change rating. As used in this report, disqualifying refers to the determination that the sailor's hearing ability does not meet minimum hearing ability required for the rating.

(d) The combined testing and audiometric evaluation process is shown as flow charts on figures 1 and 2, Appendix E.

(4) The cost of the annual audiogram is summarized in table 5.2. The detailed costs are based on the following:

(a) The audiometric technician is a sailor with an E-4 pay-grade and performs the hearing protective device (HPD) check and health education in groups with an average productivity rate of 4 patients per hour, not including the audiogram. The sailor undergoing audiometric testing is, on the average, an E-4 pay grade.

(b) The cost of the audiogram is from the CHAMPUS maximum allowable charge (CMAC) published in the DoD (Tricare) website (reference 5) for Baltimore, MD. The site lists costs according to the American Medical Association's current procedural terminology (CPT) code by procedure (reference 6). Baltimore costs were arbitrarily chosen for the baseline model. The refined model will use geographically averaged costs.

Table 5.2. Cost of Annual Audiogram

Item	CPT code	Cost, $	Comment
HPD + education	none	7.30	15 min for E-4
Audiogram	92552	19.08	For Baltimore
Issue earplug	none	20.00	Year's supply, disposable earplugs
Patient sailor's time	none	44.87	1.5 hr for E-4
Check for STS, hearing aid, and disqualifying criteria	none	0.00	Performed automatically by DOEHRS-HC software
	Total	91.25	

(5) The cost of the follow-up audiogram is in table 5.3. The baseline audiogram is reestablished after the STS has been confirmed as valid. The STS will consist of the noise induced portion and the aging portion accrued subsequent to the time of the baseline audiogram.

Table 5.3. Cost of Follow-Up Audiograms

Item	CPT code	Cost, $	Comment
1st follow-up (f/u) audiogram	92552	19.08	
Patient sailor's time	none	44.87	1.5 hr for E-4
2nd f/u	92552	19.08	Assume on same day as f/u 1
Audiologist consult	none	58.91	45 min for O-4
Reset baseline audiogram, report STS	none	0	Automatic in DOEHR-HC

d. Costs of hearing aid issue.

(1) Costs associated with patient hearing aids evaluation and issue are listed in tables 5.4 and 5.5.

(2) The items in table 5.4 constitute the hearing aid (HA) test series. This is a typical group of tests which an audiologist would use to determine if hearing aids are appropriate for a patient. Some evaluations may involve fewer or more items but this series is judged as typical by practitioners.

Table 5.4. Hearing Aid (HA) Test Series

Item	CPT code	Cost, $
Pure tone air and bone	92553	28.62
Speech awareness (SRT)	92555	16.68
Speech recognition	92556	25.01
Impedance	92567	23.00
Acoustic reflex	92568	16.68
Total (based on Baltimore) costs		109.99

(3) The items in tables 5.5 are the 5-year costs of selection and issue of hearing aids to a patient judged an appropriate candidate base on the HA test series. The patient is re-evaluated and the HA are replaced every 5 years.

Table 5.5. 5-Year Costs of HA Selection and Issue

Item	CPT code	Cost, $
Hearing aid test series (HA set)	HA set	109.99
HA exam and select	92591	83.27
Electro-acoustic evaluation	92595	76.26
Issue HA	none	1,000.00
HA check, binaural	92593	61.63
Years 2, 3, 4, 5 repeat HA set	HA set	109.99
and check	92593	61.63
5 years supply of batteries	none	(10¢ per day) 182.50
Annual average		440.03

e. Estimation of rates and probabilities for HCP and medical costs.

(1) The Navy HCP overhead cost is considered a per enrollee item and is independent of any other factor. Its probability is 100 percent.

(2) All other Navy HCP and medical costs are dependent on other factors.

(a) The annual audiometric testing mandated for all HCP enrollees accrues only if they show up.

(b) Additional costs for STS-related referrals, or disqualifying out are triggered if the HLs meet certain criteria. These costs are thus conditional on the results of the annual audiometric test.

(c) Cost estimation requires the computation of the probability distributions of HL at various frequencies and the rates and probabilities for other events as summarized in table 5.6. For conceptual convenience, probabilities calculated from the HL algorithm are designated as p() and are in the form of probability distributions. Probabilities or rates derived from other sources are designated as r() and usually in the form of constant values.

Table 5.6. Summary of HCP and Medical Rates and Probabilities

Nomenclature	Definition	Estimated value or source
r(comp)	Rate of compliance with annual audiometry	0.72
p(realSTS)	Probability of a real (unresolvable) STS	HL algorithm
r(funoshow)	Rate of no-shows for first follow-up (f/u 1) audiogram	0.60
r(falseSTS)	Rate of false positive STS in periodic audiogram	0.13
r(furepeat)	Rate of need for repeat follow-up	0.60
r(AudiologistConsult)	Rate of audiologist consult for unresolved STS	0.5
p(HArefer)	Probability of exceeding HA criteria	HL algorithm
r(HAissue)	Rate of issuing HA	0.15 to 0.60

(3) Results from a DOEHRS-HC data repository query for the 18 month period starting on January 2004 are summarized in table 5.7 (reference 7). These results were used to estimate some of the rates in table 5.6 as discussed below.

Table 5.7. DOEHRS-HC Data Call For Navy Military Periodic Audiogram Testing

Item	Population	Number	Number
Time interval		18 months, Jan 04 thru Jun 05	6 months, Jan 05 thru Jun 05
No. of total periodic audiograms	Military	311,500	216,405
No. with STS on periodic audiogram	Military	49,801	4,717
No. with STS on follow-up 1	Military		754
No. with temporary threshold shift (TTS)	Military	9,796	
No. with permanent threshold shift (PTS)	Military	40,005	
No. with reestablished DD2215	Military	3,803	724
No. without follow-up (f/u) 1 test	Military	30,031	3,504
No. without f/u 2 test	Military	7,958	
No. f/u 1 with STS resolved	Military	1,838	452
No. of total periodic audiograms	Military and Civilian	378,767	267,051

(a) For the baseline model, the rate of compliance with periodic (annual) testing, r(comp), was estimated using the total periodic audiograms for both Navy military and civilians for the 18 month period, normalizing to 12 months, and divided by the total population in the Navy HCP for 2004 (see table 5.1). For the refined model, the compliance rate for military enrollees will be used. For the “should cost” case, r(comp) would be 1.0.

(b) The rate of no-shows for first follow-up (f/u 1) audiogram, r(funoshow), is the number of no-shows divided by the number of audiograms with STS. For the “should cost” case, r(funoshow) would be 1.0.

(c) The rate of false positive STS on the annual audiogram is estimated from the data in table 5.7 as follows:

- There are 49,801 STS indications out of 311,500 periodic audiograms resulting in an apparent STS rate of 0.16.

- Since 30,031 of the 49,801 did not have a follow-up test, 19,770 did have a follow-up test. Of those with follow-up tests, 3,803 have reestablished baseline audiograms, meaning that they had a true STS. The rate of true STS among those with indicated STS is 0.19.

- The rate of false positive STS among all those receiving an annual audiogram is 0.16 times 1.0 minus 0.19, which is 0.13.

(d) The rate of need for repeat follow-up, r(furepeat), is estimated from the number that had f/u 1 and the number without f/u 2. Since f/u 2 is usually performed immediately after f/u 1, the only consequence of r(furepeat) is the added cost of one audiogram in 60% of the cases.

(e) In the Navy, not all cases of verified STS are referred to an audiologist. The rate of referral, r(AudiologistConsult) is about 0.5 according to practitioners. For the “should cost” case this would be 1.0.

(4) Table 5.8 combines the HCP costs and their rates/probabilities with the clinical test sequences from figure 2 to derive the expected value net annual HCP cost. Both baseline model and “should cost” cases are listed. Two factors of note are:

(a) The individual annual cost is dependent on the existence of an STS during the annual audiogram. Since the computation cycle is one year and the STS is based on the predicted HL, the p(realSTS) is either 0 or 1.0 for any one year.

(b) The r(falseSTS) is assumed as a constant and is 0.13 for the baseline model. This leads to a total probability of STS of 1.13 in some years for the “should cost” case. This is physically impossible for a given year but is computationally necessary to fully account for the cost of the overall false STS rate.

Table 5.8. Expected Values in the Cost Algorithms for Monitoring Audiometry and STS-Related Tests

Item (occurring annually)	**Cost of item, $**	**Applicable rates and probabilities**	**Values of rates and probabilities for the baseline model**	**Expected value cost for baseline model, $**	
				STS	**no STS**
Annual audiogram	91.25	r(comp)	.72	65.70	65.70
STS indication	0	r(comp) x [p(realSTS) + r(falseSTS)]	.72 x [p(realSTS) + .13]	0	0
Showed up for f/u 1	63.96	[1-r(funoshow)] x r(comp) x [p(realSTS) + r(falseSTS)]	.4 x .72 x [p(realSTS) + .13]	20.82	2.39
Needed 2nd f/u	19.08	r(furepeat) x [1-r(funoshow)] x r(comp) x [p(realSTS) + r(falseSTS)]	.6 x .4 x .72 x [p(realSTS) + .13]	3.73	1.43
STS not resolved	0	r(comp) x p(realSTS)	.72 x p(realSTS)	0	0
Referred to audiologist	58.91	r(comp) x p(realSTS) x r(AudiologistConsult)	.72 x p(realSTS) x .5	21.21	0
			Total cost for nominal example, $	111.46	69.52
		“Should cost” example has: 100 % compliance, r(comp) = 1.0 no no-shows, r(funoshow) = 0.0	**Values of rates and probabilities for “should cost” example**	**Expected value cost for “should cost” example, $**	
				STS	**no STS**
Annual audiogram	91.25	100 % compliance	1.0	91.25	91.25
STS indication	0	[p(realSTS) + r(falseSTS)]	p(realSTS) + .13	0	0
Showed up for f/u 1	63.96	[p(realSTS) + r(falseSTS)]	p(realSTS) + .13	72.27	8.31
Needed 2nd f/u	19.08	r(furepeat) x [p(realSTS) + r(falseSTS)]	.6 x [p(realSTS) + .13]	12.94	1.49
STS not resolved	0	p(realSTS)	p(realSTS)	0	0
Referred to audiologist	58.91	p(realSTS) x r(AudiologistConsult)	p(realSTS) x .5	29.46	0
			Total cost for ”should cost” example, $	205.92	101.05

(5) The issue of hearing aids is a medical procedure and is only attributable to the high noise exposure if the patient is enrolled in the Navy HCP. The issue of HA is also assumed to be independent of the HCP annual audiometric testing. Criteria for hearing aid issue are based on the absolute HLs. In practice, hearing aids are not issued based on HL values alone. Other tests and evaluations are made before the audiologist can determine if hearing aids are appropriate. However, algorithms for predicting these other factors as a function of HL are not available. The practitioners suggest the following formulation for a HL-based decision criterion for hearing aids.

(a) For HLs for 1 thru 4 kHz, determine L, the highest average of any two adjacent frequencies.

(b) Then if L = 30 dB, expect to issue hearing aids about 15%. The probability of issuing hearing aids doubles for every 10 dB increase in L.

(c) For the refined model the above probabilities can be verified and updated as follows: use the DOEHRS-HC database to define a population of sailors with these types of HL profiles; query the Ambulatory Data Module of the Composite Health Care System (CHCS I and II) clinical visit databases to determine which of these individuals were issued hearing aids; use these data to develop the refined probabilities of issuing HA.

f. The results of the annual audiogram sometimes lead to physician referrals which incur medical costs. These costs are not included in the model because the condition so referred is not the result of high steady-state occupational noise exposure.

6. COSTS ASSOCIATED WITH EARLY CAREER REASSIGNMENT DUE TO HEARING LOSS

a. Disqualifying of a sailor due to hearing loss leads to premature change in rating and incurs retraining costs. If job-qualifying hearing criteria exist, the probability of exceeding them, p(disqualify), can be estimated from the HL algorithm and the criteria.

b. The cost of disqualifying someone out of their rating are those associated with the specialized training which the Navy provided this individual and will now have to be provided to the replacement. The disqualified individual will still be in the Navy so recruiting and basic training costs are not lost.

c. Table 6.1 defines the information needed to calculate the increase in training costs due to NIHL. This is usable for the refined model.

d. The following normal career progression is postulated if the sailor is not disqualified: enlistment, basic training, specialized training, working in specialty for some average time period (AVGTIME), leaving the specialty for some reason other than disqualifying (promotion, retirement, ending enlistment, etc). The cost of specialized training (TRAIN$) can be amortized over the sailor's tenure in the rating as an average annual training cost.

Table 6.1. Information needed to Estimate Costs Associated with Disqualifying Out

Nomenclature	Definition	Estimate or source
TRAIN$	Cost of specialized training by NEC	NAVEDTRACOM handbook, (reference 8)
AVGTIME	Average time the sailor is in the rating, not to include those disqualified for hearing, years	Navy's Enlisted Master Records
Disqualifying criteria	Criteria for disqualifying out based on hearing level standard	Fitness standards for rating (if available)
p(disqualify)	Probability of exceeding disqualifying criteria	HL algorithm, noise level
PROFTIME	Expected average time for sailor to fail minimum hearing standard, years	Calculated from p(disqualify)
r(NOTwaiver)	Rate of not waiving disqualifying	0.0 for baseline model

e. If a sailor is disqualified early at some time (PROFTIME), the actual amortized training cost will be higher than normal. The economic cost of the disqualifying is:

Cost of disqualifying =r(NOTwaiver) × TRAIN$[1-(PROFTIME ÷ AVGTIME)]

f. According to the practitioners, most Navy ratings do not have specific hearing-related qualifications criteria and, where there are hearing criteria, reassignments due to failure of sailors to meet the criteria are very often waived. This is equivalent to assuming in the baseline model that r(NOTwaiver) for hearing-related disqualification is close to 0.0. These considerations are largely deferred to the refined model but a hypothetical example is included in section 8.

7. COSTS ASSOCIATED WITH ENROLLMENT IN THE DEPARTMENT OF VETERANS AFFAIRS OF PROGRAMS

a. General considerations.

(1) The VA Audiology Handbook (reference 9) indicates that benefits accrue only if incurred or aggravated during military service. Incurred in service means that hearing was normal at induction and was found to be damaged by military service. Aggravated means that hearing was not normal, but was acceptable for induction and was found to have worsened due to military service (reference 10).

(2) The normal progression is (reference 9): the veteran makes an application based on hearing loss at a veteran Service Center (VSC). If warranted, the VSC orders an audiology compensation and pension (Audio C&P) examination. The results are evaluated by the VSC and medical and/or compensation benefits may ensue as determined by the VSC.

(3) Modeling of the VA costs attributable to the high noise exposure consists of:

(a) Generating HLs and probabilities for the noise exposure of interest.

(b) Estimating costs of medical and compensation benefits accruing to veterans with the estimated HLs. Although VA medical and VA compensation costs are somewhat related to each other, it is more convenient to examine them separately.

(c) Devising HL-based criteria reflective of the VSC service-connectedness decision process.

b. The VA medical costs.

(1) The medical procedures and CPT codes used in VA audiology are listed in table 7.1. Cost information in these areas and for the Audio C&P test has been requested from the VA but not yet available.

Table 7.1. VA Audiology Procedures

Nomenclature	**CPT code**	Cost, $
Pure tone audiometry (threshold) air only	92552	TBD
Pure tone audiometry air and bone	92553	TBD
Speech audiometry threshold	92555	TBD
Speech audiometry threshold with speech recognition	92556	TBD
Comprehensive audiometry threshold evaluation (92553 plus 92556)	92557	TBD
Strenger test, Pure tone	92565	TBD
Tympanometry (impedance testing)	92567	TBD
Acoustic reflex testing	92568	TBD
Acoustic reflex decay testing	92569	TBD
Strenger test, Speech	92577	TBD
Otoacoustic emission	92588	TBD
Hearing aid examination and selection, monaural	92590	TBD
Hearing aid examination and selection, binaural	92591	TBD
Hearing aid check, monaural	92592	TBD
Hearing aid check, binaural	92593	TBD
Electroacoustic evaluation for hearing aid; monaural	92594	TBD
Electroacoustic evaluation for hearing aid; binaural	92595	TBD
Rehabilitation status examination	92626	TBD
Rehabilitation status examination	92627	TBD
Aural rehabilitation for post-lingual hearing loss	92633	TBD
Checkout for orthotic/prosthetic use, established patient, 15 min	97703	TBD
Disability examination	99456	TBD

(2) In the interim, the following estimating procedure can be used for illustration purposes in running examples:

(a) Assume that the portion of VA medical benefits attributable to Navy noise exposure is the same as the Navy medical benefit attributable to Navy exposure, including the HL-based probabilities. In that case the total Navy medical cost is the annualized hearing aid cost of $440.03 per year which includes costs of the device, professional services, follow-up services, batteries, repairs, and replacements.

(b) The Audio C&P exam appears somewhat similar to the Navy HA test. Assume a cost of $110. This is assumed to be a one-time event for each veteran.

c. The VA compensation benefits process is summarized in table 7.2.

Table 7.2. VA Compensation Costs

#	Item	Probability	Comment
1	Applies for benefits and given audio C&P exam	1.0	Assume all veterans file once in their lifetime
2	VSC determines eligibility for disability compensation based on percentage evaluations for haring impairment (PEHI)	1.0	Assume all veterans file once in their lifetime
3	If eligible, awarded compensation	p(compensation)	Estimated using HL algorithm and criteria in the VA Audiology handbook. Cost criteria include % disability, other disabilities, dependents, life expectancy, tax rates

(1) The compensation is based on the results of the audiological evaluation which determines the % disability from hearing loss.

(a) The VA assigns a value of percent disabled based on a combination of HLs, % speech discrimination, and symmetry of right and left ear HLs (reference 9). The VA also provides guidelines for cases where only HLs are available.

(b) Since only HLs are predicted by the HL algorithm, the VA's specified HL-only guidance is used in the model (table VIa of reference 9).

(c) The disability rating is somewhat keyed to the better ear. Since the noise exposure is steady-state and relatively omni-directional, it is assumed that the HLs for the subject veteran sailors are symmetrical.

(d) The VA makes special provisions for exceptional HL patterns. For example, if the HL is 30 dB at 1 kHz, and 70 dB or greater at 2 kHz then the percent disabled is raised by one increment. These patterns are not predictable by the HL algorithm, and therefore this VA procedure is not part of the cost model.

(2) The relation between HLs and the % disability is summarized in table 7.3. (from the VA Audiology Handbook). This is a simplified relationship since it includes the following assumptions: the HLs are symmetrical, VA tables for HLs only are used (no speech discrimination data), no exceptional HL patterns are considered.

Table 7.3. Simplified Relation between Hl and VA % Disability

Average HL 1, 2, 3, 4kHz	0 - 55	56 – 62	63 – 69	70 – 77	78 - 83	84 – 90	91 – 97	98 – 104	105 +
% disability	0	10	20	30	40	50	60	80	100

(3) The current (as of 1 Dec 2004) monthly compensation rates are specified in the VA Fast Letter (reference 11). For disability of 30% and higher the compensation rates are increased if the veteran has dependents such as spouse, children under 18, helpless children of any age, or dependent parents. There are some other complex VA policies which bear on the economic cost of compensation. They include:

(a) Combat-Related Special Compensation (CRSC) - Current law prohibits the concurrent payment of VA disability compensation and military retired pay. Compensation is offset by military retired pay. This means that a veteran drawing military retirement pay will not receive any net increase in gross pay when claiming service-related disability compensation. However, the disability compensation is tax free so there will be a net cost to the U.S. treasury equal to the disability compensation times the veteran's marginal income tax rate. The CRSC benefits are equal to the amount of VA disability compensation offset from retired pay based on those disabilities determined to be combat-related.

(b) Concurrent Retirement and Disability Payments (CRDP) – this program provides a 10-year phase-out of the offset to military retired pay due to receipt of VA disability compensation for disabled veterans whose combined disability rating is 50% or greater. Effective January 1, 2005, those retirees rated 100% are entitled to receive both the full amount of VA compensation and military retired pay with no phase-out period.

(c) When a veteran has more than one type of disability the total % disability is not additive. It accumulates based on remaining functionality. The net effect is that the total disability is less than the arithmetic sum of the individual disabilities.

(d) Additional allowance is paid if the veteran has a spouse who is in need of regular aid and attendance (A/A spouse).

(4) The above VA policies require considerable demographic data to implement precisely into the cost model. Such data can be available from the VA by special request but may or may not add much to the utility of the model. The baseline model includes the following simplifying assumptions resulting in the set of allowance costs shown in table 7.4:

(a) The complex VA allowance table is simplified by combining all classes of dependents into one average allowance per dependent. The veteran's family is assumed to be in line with the U.S. Census Bureau's average; i.e., the family consists of the veteran plus 2.18 dependents (reference 12). The allowance rate per dependent is the average value for the 3 separate types of dependents recognized by the VA.

(b) Use a marginal tax rate of 15% which is valid for married filing jointly with taxable income between $14,600 and $59,400 (reference 13). This applies to 10 to 40% disabilities. For higher disabilities, there will eventually be no offset. This forward looking model does not reflect any compensation offset above 40% disability. That is: for veterans with 10 to 40% disability only 15% of the disability compensation is included as a cost; for veterans with greater than 40% disability the full disability compensation is included in the cost estimate.

(c) The A/A spouse allowance, combat-related hearing loss, and effects of combined disabilities are disregarded. These would tend to offset each other.

(d) The compensation benefits last until death of the veteran. For the baseline model, general U.S. life expectancies are available from the Centers for Disease Control and Prevention (reference 14). For the refined model, the VA can be asked for statistical data specific to veterans.

Table 7.4. Simplified Costs of Veterans' Disability Compensation, Includes 2.18 Dependents

% disability	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**80**	**100**
Average HL 1, 2, 3, 4kHz	<56	56 - 62	63 - 69	70 - 77	78 - 83	84 - 90	91- 97	98 - 104	105 +
Cost per month, $	0	108	210	389	553	772	970	1,402	2,407
% not offset	15	15	15	15	15	100	100	100	100

d. Modeling the VA service-connectedness of HL.

(1) Practitioners at the VA Audiology and Speech Pathology Service have provided considerable technical information of the VA service-connectedness decision process for hearing loss (reference 10 and appendix D):

(a) Benefit decisions are not based solely on exist audiograms.

(b) The standard of evidence is "as likely as not" which is generally regarded as 50/50 probability.

(c) There is no statute of limitations on filing claims.

(d) VA ratings are not age adjusted; nor is it appropriate to age-adjust hearing thresholds using population norms (ISO 1999 or ANSI S3.44 1996).

(e) Detailed information and some approaches to modeling the decision process were provided. These are shown in appendix D.

(2) The factors and considerations outlined in the VA information indicate a very complex and nuanced process with considerable provision for professional judgment on the part of the audiologist. A simplified approach for the baseline model is developed by bracketing the cost outcomes. Table 7.5 lists three possible approaches.

(a) The HL-based approach is very permissive in that all HL is compensated. There is no provision for disallowing the effect of non-service connected noise exposure.

(b) The exit HL-based approach is very restrictive and appears to be in violation of VA policy.

(c) The STS-based approach is selected for the baseline model because it appears to be the most reasonable and in line with VA policy. Additional consultation with VA is required before defining the VA service-connectedness decision criteria for the refined model.

Table 7.5. Comparison of Three Approaches to Modeling Service-Connectedness Decisions Using Predicted Hl

Type	**Principal feature**	**Possible rationale**	**Pros and cons**
All HL-based	Base eligibility on HLs regardless of when measured	The documented exposure to high noise levels and inclusion in the Navy HCP indicate that at least some of the HL is service connected and aggravates the HL after retirement	Pro- absolutely follows principle of aggravation Con- compensates any and all non-service-related exposures and aging
Exit HL-based	Base eligibility only on HLs in exit audiogram	All HL after separation is presumed to be age-related and/or produced by non-service noise exposure	Pro- avoids costs of non-service connected exposure Con- ignores the principle of aggravation and implicitly applies age-correction to HL, both in contradiction to established VA policy
STS-based	Base eligibility on HLs regardless of when measured only if sailor had an STS during active duty	Use the STS record as objective evidence of noise-induced hearing loss sustained in service	Pro- attempts to objectively identify noise induced HL based on in-service audiogram records and eliminate non-service connected HL Con- STS dB values are somewhat arbitrary

e. Tinnitus.

(1) The model does not address the VA costs of tinnitus disability compensation.

(2) Tinnitus would require an algorithm similar to the HL algorithm linking tinnitus to noise exposure level and exposure duration. No such relation appears available. Any adjustment, such as by using a straight ratio of VA HL costs to VA tinnitus costs, would be quite arbitrary. The factor would be approximately 70%.

f. VA overhead costs.

(1) Overhead associated with the VA benefit costs are estimated using data from the VA's FY 2005 Annual Performance and Accountability Report (reference 16). The overhead rate is a multiplier applied to the benefit payable to the veteran to obtain the estimate of the economic cost to the U.S. treasury. The only VA costs incurred as a result of steady noise exposure are for medical care and compensation. Even though the compensation is in the form of monthly payments, it is compensation and does not fall under the VA pension program.

(2) The VA costs data in reference 16 are listed by VA program. Within most programs, the costs are further broken down as to benefits and administrative categories. This structure indicated a two part overhead rate: a within program overhead; and an overall overhead.

(a) Table 7.6 summarizes the costs by VA program as listed in Part II, table 2 of reference 16. Most of the listed VA programs involve direct benefits to the veteran. Three programs, Board of Veterans' Appeals, Departmental Management, and Office of Inspector General, appear to be overhead functions. The overall overhead rate of 1.17 percent is estimated by dividing the costs of these non-benefit programs ($882,000,000) by the total cost of the benefit programs ($75,088,000,000).

Table 7.6. VA Cost by Program for FY 2005 from Reference 16 Part II, Table 2

Program	**Item**	**Type of cost**	**Cost in millions of $**
Veterans Health Administration	Medical care	Benefits cost	$31,668
	Medical Research	Research cost	$1,033
Veterans Benefits Administration	Compensation	Benefits cost	$28,768
		Administrative cost	$834
	Pension	Benefits cost	$3,408
		Administrative cost	$165
	Education	Benefits cost	$3,329
		Administrative cost	$84
	Vocational Rehabilitation and Employment	Benefits cost	$552
		Administrative cost	$137
	Housing	Benefits cost	$1,927
		Administrative cost	$153
	Insurance	Benefits cost	$2,573
		Administrative cost	$41
National Cemetery Administration		All costs	$416
		Total of benefits program costs	**$75,088**
Board of Veterans' Appeals		Administrative cost	$50
Departmental Management		Administrative cost	$762
Office of Inspector General		Administrative cost	$70
		Total of non-benefits program costs	$882

(b) The overhead rate within the compensation program is estimated by dividing the Veterans Benefits Administration compensation administrative cost by the compensation benefits cost. This results in a compensation program overhead rate of 2.9 percent.

(c) The Veterans Health Administration costs were not broken down in the source table for reference 16. However, Part III section 3 tabulates the obligations incurred for the Veterans Health Administration as summarized in table 7.7. Medical research is somewhat arbitrarily not considered as overhead because it is congressionally funded and therefore not an indirect cost of providing benefits to veterans. The Veterans Health Administration programmatic overhead rate is 37.6 percent.

Table 7.7. Veterans Health Administration Obligations
Incurred for FY 2005 from Reference 16 Part III, Section 3

Type of cost	**Cost in millions of $**
Medical care	$23,081
Medical research	$467
Total medical care and research	**$23,548**
Administration	$4,400
Facilities	$3,303
Other	$1,142
Total non-benefit/research	**$8,845**

(d) The total overhead rate for VA compensation benefits is 4.1 percent and for VA medical benefits is 39.2 percent.

8. NUMERICAL EXAMPLES

a. Computation Outline.

(1) Computation of the costs for the nominal example uses a finite element approach. The probability distribution of susceptibility to noise is broken up into discrete intervals and the HLs at the center of each probability interval are used to represent the whole interval. Probabilities are expressed in terms of the fractile of the susceptibility with 1.0 representing the least susceptible.

(2) The expected value of the cost for each interval is the total cost for the center HL times the probability interval. The intervals do not have to be equal. The highly susceptible portion of the distribution will incur the greatest costs so smaller intervals are used at that end of the distribution. For this example, the increments are 0.01 up to the 0.1 fractile and 0.02 for fractiles between 0.1 and 1.0.

(3) Tables 8.1 through 8.10 contain the detailed values for each year and each computational step for the 0.005 fractile of the nominal example. Expected values of the costs for the nominal example are in table 8.11. For the sake of clarity, the discussions for the example are detailed and somewhat repetitive of previous sections of this report.

(4) Cost estimates are also listed in table 8.13 for variations from the nominal example including:

(a) More time at sea.

(b) Less time at sea.

(c) Exposure to levels 5 dB higher.

(d) No noise exposure (aging only).

(e) Using all HL-based criteria for VA eligibility (see table 7.5).

(f) Using service exit HL-based criteria for VA eligibility (see table 7.5).

(g) Retraining costs (hypothetical example).

b. Nominal Career Profile for the Example. A sailor enlists at 18 years of age, receives basic and advanced training, becomes a machinist's mate (MM), is assigned to a carrier machinery space, retires after 20 years of service, and dies at 77.

(1) The average noise level to which the MM is exposed is 95 dBA; the watch pattern is 12 hours on, 12 hours off, 7 day per week.

(2) As discussed in reference 2, an exposure of 95 dBA for 12 hours per day, 7 day per week is equivalent to a 5 day per week, 40 hour per day exposure 8-hour TWA of 98 dBA. This Navy exposure pattern will generate the same HLs as a 93 dBA TWA exposure per ANSI S3.44-1996 when the exposure interval (in years) is the actual time at sea.

(3) The nominal assignment rotation for this example includes sea and land duty. The sea duty consists of 6 months at sea and 6 months dockside. For the nominal case, each year of sea duty counts as 0.5 years of noise exposure.

c. Timeline and Estimates of Hearing Level.

(1) Table 8.1 shows the career outline and the noise-related landmark events for the nominal case. The HLs are estimated by combining the ANSI hearing threshold level from aging (HTLA) and noise-induced permanent threshold shift (NIPTS). These are also shown on table 8.1 for the 0.005 fractile and an ANSI exposure of 93 dBA TWA.

(2) The HTLAN is shown in table 8.2. It was obtained using the ANSI S3.44 method for combining HTLA with NIPTS for each fractile to obtain the hearing threshold level from aging and noise (HTLAN), i.e., the following equation:

$$HTLAN = HTLA + NIPTS - [HTLA \times NIPTS \div 120]$$

(3) As noted in 4c, HTLANs were limited to 110 dB. Also, whenever the 2 kHz NIPTS exceeded the 3 kHz value, the 3 kHz value was used in the calculations.

d. Navy Monitoring Audiometry and STS Costs.

(1) All enrollees in the Navy HCP receive annual monitoring audiograms and the cost is shown on tables 8.2 and 8.3. This cost includes allowances for the follow-up testing resulting from false positive significant threshold shift (STS). Such occurrences are characterized by an indicated STS which is resolved through follow-up tests. The calculation of the allowance is outlined in table 5.8. The total includes a compliance rate of 72% for monitoring audiometric tests and a 100% percent compliance rate for Navy HCP overhead and Navy hearing aids.

(2) The true STS is characterized by an irresolvable STS and a reestablished baseline audiogram. The costs of audiometric testing are influenced by the compliance rate [r(comp)] and other rates and probabilities. These costs are calculated as outlined in table 5.8 and include the cost of referral to an audiologist.

e. Cost of Hearing Aid Evaluation and Issue.

(1) The annualized cost of hearing aid (HA) testing and issue was estimated as $440.03 (see paragraph 5c and table 5.5). Table 8.3 shows the application of the criteria for eligibility as discussed in 5f.

(2) A column for testing the hypothetical disqualifying out criteria is included in table 8.3. The results have no effect on the costs in the nominal example. They are used for a separate computation of hypothetical retraining costs.

f. Costs of VA Benefits. The nominal example uses the STS-based service-connectedness criteria as the nominal case. Since the 0.005 fractile case did sustain an STS (twice), all HL are considered service connected, even those arising in the veteran's later years. The resulting costs for this fractile are the same as those that would result if the permissive assumption with respect to the VA service-connectedness decision were used. That is, all hearing loss after retirement is assumed service-connected for this fractile. For this nominal example STS is sustained for all fractiles through 0.68.

(1) The sailor has 2.18 dependents, retires at 38, and enters VA purview after 20 years of service.

(a) The average life expectancy for a 38-year old male is 77 years. Tables 8.4, 8.5, 8.6, and 8.7 list the HTLA, NIPTS, and HTLAN for the veteran sailor by year.

(b) The VA audiological compensation and pension examination is assumed to cost $110.00. This charge is incurred in the first year of retirement for all fractiles.

(c) The VA medical benefits for hearing loss due to steady noise exposure are assumed limited to issue of hearing aids. In the lack of VA cost data, it is assumed that the annual costs are $440.03, the same as for the Navy, and are listed in tables 8.6 and 8.7. The VA medical costs are essentially a continuation of the Navy hearing aid (HA) costs.

(2) The VA criterion for considering hearing level to be a disability is: HL at any of 500, 1000, 2000, 3000, or 4000 Hz of 40 dB or greater or average of any three HLs of 26 dB or greater. Columns 2 thru 5 of tables 8.8 and 8.9 test for this criterion.

(3) The steps in estimating VA compensation benefits are in columns 6, 7, 8, and 9 of tables 8.8 and 8.9. These follow the simplified criteria for as discussed in table 7.4.

(4) Columns 9 and 10 of tables 8.10 and 8.9 calculate the economic consequences of the tax implications of the compensation offset on the retiree's pension.

(5) Columns 12 and 13 are the total annual and total cumulative costs of the sailor's noise exposure for the 0.005 fractile of susceptibility. The progression over years after enlistment of the various cost classes for the 0.005 fractile is plotted in figure 3.

Table 8.1. Navy Career Profile and Hearing Threshold Levels for 0.005 Fractile of Susceptibility

Age	Yrs in noise	Event/assignment	Noise, TWA	Hearing threshold level from aging, dB						Noise-induced permanent threshold shift, dB					
				500	1,000	2,000	3,000	4,000	6,000	500	1,000	2,000	3,000	4,000	6,000
18	0	Enlists, baseline audiogram	70.0	15.8	15.8	18.6	20.0	21.5	24.3	0.0	0.0	0.0	0.0	0.0	0.0
19	0	Training	70.0	15.8	15.8	18.6	20.1	21.5	24.4	0.0	0.0	0.0	0.0	0.0	0.0
20	0.5	6 mo at sea	93.0	15.8	15.8	18.7	20.1	21.6	24.5	0.0	0.8	14.4	3.6	4.7	8.8
21	1	6 mo at sea	93.0	15.8	15.8	18.8	20.3	21.8	24.7	0.0	1.1	14.5	8.2	8.9	11.8
22	1.5	6 mo at sea	93.0	15.9	15.9	18.9	20.4	22.0	25.0	0.0	1.3	14.7	11.3	11.7	13.7
23	2	6 mo at sea	93.0	16.0	16.0	19.0	20.7	22.3	25.3	0.0	1.5	14.9	13.5	13.9	15.2
24	2.5	6 mo at sea	93.0	16.0	16.1	19.2	20.9	22.7	25.7	0.0	1.6	15.0	15.4	15.6	16.4
25	2.5	Shore	70.0	16.1	16.2	19.4	21.2	23.2	26.2	0.0	1.6	15.0	15.4	15.6	16.4
26	2.5	Shore	70.0	16.2	16.3	19.6	21.6	23.7	26.8	0.0	1.6	15.0	15.4	15.6	16.4
27	3	6 mo at sea	93.0	16.4	16.5	19.8	22.0	24.3	27.5	0.0	1.7	15.1	16.9	17.1	17.5
28	3.5	6 mo at sea	93.0	16.5	16.6	20.1	22.5	24.9	28.2	0.0	1.8	15.2	18.2	18.4	18.3
29	4	6 mo at sea	93.0	16.7	16.8	20.4	23.0	25.6	29.0	0.0	1.8	15.4	19.4	19.6	19.1
30	4.5	6 mo at sea	93.0	16.8	17.0	20.8	23.6	26.4	29.9	0.0	1.9	15.4	20.4	20.6	19.8
31	4.5	Shore	70.0	17.0	17.2	21.2	24.2	27.3	30.9	0.0	1.9	15.4	20.4	20.6	19.8
32	4.5	Shore	70.0	17.2	17.4	21.6	24.9	28.2	31.9	0.0	1.9	15.4	20.4	20.6	19.8
33	4.5	Shore	70.0	17.5	17.7	22.0	25.6	29.2	33.0	0.0	1.9	15.4	20.4	20.6	19.8
34	5	6 mo at sea	93.0	17.7	18.0	22.5	26.4	30.3	34.2	0.0	2.0	15.5	21.4	21.5	20.5
35	5.5	6 mo at sea	93.0	17.9	18.2	23.0	27.2	31.4	35.5	0.0	2.0	15.6	22.2	22.4	21.1
36	6	6 mo at sea	93.0	18.2	18.5	23.5	28.0	32.6	36.9	0.0	2.1	15.7	23.0	23.2	21.6
37	6	Shore	70.0	18.5	18.9	24.0	29.0	33.9	38.3	0.0	2.1	15.7	23.0	23.2	21.6
38	6	VA, C&P exam	70.0												
77	6	Dies	70.0												

Table 8.2. Navy Hearing Threshold Level Aging and Noise and Audiometry Cost Estimates for the 0.005 Fractile of Susceptibility

Age	Yrs in noise	Event/assignment	Noise, TWA	Hearing threshold level, aging and noise, dB						Test for STS	Navy Cost, $	
				500	1,000	2,000	3,000	4,000	6,000		Navy HCP overhead	Annual audiogram, f/u auds and referral
18	0	Enlists, baseline audiogram	70.0	15.8	15.8	18.6	20.0	21.5	24.3	no	$12.21	$68.52
19	0	Training	70.0	15.8	15.8	18.6	20.1	21.5	24.4	no	$12.21	$68.52
20	0.5	6 mo at sea	93.0	15.8	16.5	21.7	23.1	25.4	31.5	no	$12.21	$68.52
21	1	6 mo at sea	93.0	15.8	16.8	25.7	27.1	29.0	34.0	no	$12.21	$68.52
22	1.5	6 mo at sea	93.0	15.9	17.1	28.4	29.8	31.6	35.8	no	$12.21	$68.52
23	2	6 mo at sea	93.0	16.0	17.3	30.4	31.9	33.6	37.3	yes, reset baseline	$12.21	$111.45
24	2.5	6 mo at sea	93.0	16.0	17.4	31.8	33.6	35.4	38.6	no	$12.21	$68.52
25	2.5	Shore	70.0	16.1	17.6	31.9	33.9	35.8	39.1	no	$12.21	$68.52
26	2.5	Shore	70.0	16.2	17.7	32.1	34.2	36.2	39.6	no	$12.21	$68.52
27	3	6 mo at sea	93.0	16.4	17.9	32.5	35.8	37.9	40.9	no	$12.21	$68.52
28	3.5	6 mo at sea	93.0	16.5	18.1	32.8	37.3	39.5	42.2	no	$12.21	$68.52
29	4	6 mo at sea	93.0	16.7	18.4	33.2	38.7	41.0	43.5	no	$12.21	$68.52
30	4.5	6 mo at sea	93.0	16.8	18.6	33.6	40.0	42.5	44.8	no	$12.21	$68.52
31	4.5	Shore	70.0	17.0	18.8	33.9	40.5	43.2	45.6	no	$12.21	$68.52
32	4.5	Shore	70.0	17.2	19.1	34.2	41.1	44.0	46.5	no	$12.21	$68.52
33	4.5	Shore	70.0	17.5	19.3	34.6	41.7	44.8	47.4	no	$12.21	$68.52
34	5	6 mo at sea	93.0	17.7	19.6	35.1	43.0	46.4	48.9	no	$12.21	$68.52
35	5.5	6 mo at sea	93.0	17.9	20.0	35.6	44.4	47.9	50.3	yes, reset baseline	$12.21	$111.45
36	6	6 mo at sea	93.0	18.2	20.3	36.1	45.7	49.5	51.8	no	$12.21	$68.52
37	6	Shore	70.0	18.5	20.6	36.6	46.4	50.5	53.0	no	$12.21	$68.52
38	6	VA, C&P exam										
77	6	Dies										

Table 8.3. Navy Medical Cost Estimates for the 0.005 Fractile of Susceptibility

Age	Yrs in noise	Event	Noise TWA	Max avg adjacent in 1 to 4 kHz	Navy or VA prob of HA for year	Navy or VA cum prob of HA	Navy or VA cost of HA for year ($440.03 avg)	(Hypothetical) test for disqualifying out of rating	Navy summation including r(comp) = .72	Navy HC and medical cumulative
18	0	Enlists, baseline audiogram	70.0	20.8	0.000	0.000	$0.00	no	$80.73	$80.73
19	0	Training	70.0	20.8	0.000	0.000	$0.00	no	$80.73	$161.47
20	0.5	6 mo at sea	93.0	24.3	0.000	0.000	$0.00	no	$80.73	$242.20
21	1	6 mo at sea	93.0	28.1	0.000	0.000	$0.00	no	$80.73	$322.93
22	1.5	6 mo at sea	93.0	30.7	0.157	0.157	$69.18	no	$149.91	$472.85
23	2	6 mo at sea	93.0	32.7	0.181	0.310	$136.45	yes	$260.11	$732.95
24	2.5	6 mo at sea	93.0	34.5	0.205	0.451	$198.66	yes	$279.39	$1,012.34
25	2.5	Shore	70.0	34.8	0.210	0.567	$249.28	yes	$330.01	$1,342.36
26	2.5	Shore	70.0	35.2	0.215	0.660	$290.37	yes	$371.10	$1,713.45
27	3	6 mo at sea	93.0	36.9	0.242	0.742	$326.53	yes	$407.27	$2,120.72
28	3.5	6 mo at sea	93.0	38.4	0.269	0.811	$357.04	yes	$437.77	$2,558.49
29	4	6 mo at sea	93.0	39.9	0.297	0.867	$381.69	yes	$462.43	$3,020.92
30	4.5	6 mo at sea	93.0	41.2	0.327	0.911	$400.77	yes	$481.51	$3,502.43
31	4.5	Shore	70.0	41.9	0.341	0.941	$414.17	yes	$494.90	$3,997.33
32	4.5	Shore	70.0	42.5	0.357	0.962	$423.41	yes	$504.14	$4,501.47
33	4.5	Shore	70.0	43.2	0.375	0.976	$429.64	yes	$510.38	$5,011.84
34	5	6 mo at sea	93.0	44.7	0.416	0.986	$433.96	yes	$514.69	$5,526.54
35	5.5	6 mo at sea	93.0	46.1	0.459	0.993	$436.75	yes	$560.41	$6,086.94
36	6	6 mo at sea	93.0	47.6	0.507	0.996	$438.41	yes	$519.15	$6,606.09
37	6	Shore	70.0	48.5	0.539	0.998	$439.28	yes	$520.02	$7,126.11
38	6	VA, C&P exam	none							
77	6	Dies	none							

Table 8.4. Veteran Age 38 to 57 Profile and Hearing Threshold Levels for 0.005 Fractile of Susceptibility

Age	Yrs in noise	Event	Noise	Hearing threshold level from aging, dB						Noise-induced permanent threshold shift, dB					
				500	1,000	2,000	3,000	4,000	6,000	500	1,000	2,000	3,000	4,000	6,000
38	6	VA, C&P exam	none	18.8	19.2	24.6	29.9	35.2	39.8	0.0	2.1	15.7	23.0	23.2	21.6
39	6	Retired	none	19.1	19.6	25.2	30.9	36.6	41.4	0.0	2.1	15.7	23.0	23.2	21.6
40	6	Retired	none	19.4	19.9	25.9	32.0	38.1	43.0	0.0	2.1	15.7	23.0	23.2	21.6
41	6	Retired	none	19.7	20.3	26.6	33.1	39.6	44.8	0.0	2.1	15.7	23.0	23.2	21.6
42	6	Retired	none	20.1	20.7	27.3	34.3	41.3	46.6	0.0	2.1	15.7	23.0	23.2	21.6
43	6	Retired	none	20.5	21.1	28.0	35.5	42.9	48.5	0.0	2.1	15.7	23.0	23.2	21.6
44	6	Retired	none	20.8	21.6	28.8	36.7	44.7	50.5	0.0	2.1	15.7	23.0	23.2	21.6
45	6	Retired	none	21.2	22.0	29.6	38.0	46.5	52.5	0.0	2.1	15.7	23.0	23.2	21.6
46	6	Retired	none	21.7	22.5	30.4	39.4	48.4	54.6	0.0	2.1	15.7	23.0	23.2	21.6
47	6	Retired	none	22.1	23.0	31.3	40.8	50.4	56.8	0.0	2.1	15.7	23.0	23.2	21.6
48	6	Retired	none	22.5	23.5	32.1	42.3	52.4	59.1	0.0	2.1	15.7	23.0	23.2	21.6
49	6	Retired	none	23.0	24.0	33.1	43.8	54.5	61.5	0.0	2.1	15.7	23.0	23.2	21.6
50	6	Retired	none	23.5	24.6	34.0	45.3	56.6	63.9	0.0	2.1	15.7	23.0	23.2	21.6
51	6	Retired	none	23.9	25.1	35.0	46.9	58.9	66.4	0.0	2.1	15.7	23.0	23.2	21.6
52	6	Retired	none	24.4	25.7	36.0	48.6	61.2	69.0	0.0	2.1	15.7	23.0	23.2	21.6
53	6	Retired	none	25.0	26.3	37.0	50.3	63.5	71.7	0.0	2.1	15.7	23.0	23.2	21.6
54	6	Retired	none	25.5	26.9	38.1	52.0	66.0	74.4	0.0	2.1	15.7	23.0	23.2	21.6
55	6	Retired	none	26.0	27.5	39.2	53.8	68.5	77.2	0.0	2.1	15.7	23.0	23.2	21.6
56	6	Retired	none	26.6	28.2	40.3	55.7	71.1	80.1	0.0	2.1	15.7	23.0	23.2	21.6
57	6	Retired	none	27.2	28.8	41.5	57.6	73.7	83.1	0.0	2.1	15.7	23.0	23.2	21.6

Table 8.5. Veteran Age 58 to 77 Profile and Hearing Threshold Levels for 0.005 Fractile of Susceptibility

Age	Yrs in noise	Event	Noise	Hearing threshold level from aging, dB						Noise-induced permanent threshold shift, dB					
				500	1,000	2,000	3,000	4,000	6,000	500	1,000	2,000	3,000	4,000	6,000
58	6	Retired	none	27.8	29.5	42.7	59.5	76.4	86.2	0.0	2.1	15.7	23.0	23.2	21.6
59	6	Retired	none	28.4	30.2	43.9	61.5	79.2	89.3	0.0	2.1	15.7	23.0	23.2	21.6
60	6	Retired	none	29.0	30.9	45.1	63.6	82.1	92.5	0.0	2.1	15.7	23.0	23.2	21.6
61	6	Retired	none	29.7	31.6	46.4	65.7	85.0	95.8	0.0	2.1	15.7	23.0	23.2	21.6
62	6	Retired	none	30.3	32.4	47.7	67.8	88.0	99.1	0.0	2.1	15.7	23.0	23.2	21.6
63	6	Retired	none	31.0	33.1	49.0	70.0	91.0	102.6	0.0	2.1	15.7	23.0	23.2	21.6
64	6	Retired	none	31.7	33.9	50.4	72.3	94.1	106.1	0.0	2.1	15.7	23.0	23.2	21.6
65	6	Retired	none	32.4	34.7	51.8	74.6	97.3	109.7	0.0	2.1	15.7	23.0	23.2	21.6
66	6	Retired	none	33.1	35.5	53.2	76.9	100.6	113.4	0.0	2.1	15.7	23.0	23.2	21.6
67	6	Retired	none	33.8	36.4	54.7	79.3	103.9	117.1	0.0	2.1	15.7	23.0	23.2	21.6
68	6	Retired	none	34.5	37.2	56.2	81.7	107.3	120.9	0.0	2.1	15.7	23.0	23.2	21.6
69	6	Retired	none	35.3	38.1	57.7	84.2	110.8	124.8	0.0	2.1	15.7	23.0	23.2	21.6
70	6	Retired	none	36.1	39.0	59.2	86.8	114.3	128.8	0.0	2.1	15.7	23.0	23.2	21.6
71	6	Retired	none	36.9	39.9	60.8	89.4	117.9	132.9	0.0	2.1	15.7	23.0	23.2	21.6
72	6	Retired	none	37.7	40.8	62.4	92.0	121.6	137.0	0.0	2.1	15.7	23.0	23.2	21.6
73	6	Retired	none	38.5	41.7	64.1	94.7	125.4	141.2	0.0	2.1	15.7	23.0	23.2	21.6
74	6	Retired	none	39.3	42.7	65.7	97.4	129.2	145.5	0.0	2.1	15.7	23.0	23.2	21.6
75	6	Retired	none	40.2	43.7	67.4	100.2	133.1	149.9	0.0	2.1	15.7	23.0	23.2	21.6
76	6	Retired	none	41.0	44.6	69.2	103.1	137.0	154.3	0.0	2.1	15.7	23.0	23.2	21.6
77	6	Dies	none	41.9	45.6	70.9	106.0	141.0	158.8	0.0	2.1	15.7	23.0	23.2	21.6

Table 8.6 Veteran Age 38 to 57 Hearing Threshold Level Aging and Noise and VA Medical Cost Estimates for the 0.005 Fractile of Susceptibility

Age	Yrs in noise	Event	Noise	Hearing threshold level, aging and noise						Max avg HL adjacent in 1 to 4 kHz	VA prob of HA for year	VA cum prob of HA	VA cost of HA for year ($440.03 avg plus overhead)	VA medical cumulative
				0.5 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz					
38	6	C&P exam	none	18.8	20.9	37.1	47.2	51.6	54.2	49.4	0.575	0.999	$612.08	$612.08
39	6	Retired	none	19.1	21.3	37.6	48.0	52.7	55.5	50.4	0.615	1.000	$612.35	$1,224.43
40	6	Retired	none	19.4	21.6	38.2	48.9	53.9	56.9	51.4	0.660	1.000	$612.46	$1,836.90
41	6	Retired	none	19.7	22.0	38.8	49.8	55.2	58.3	52.5	0.711	1.000	$612.51	$2,449.40
42	6	Retired	none	20.1	22.4	39.4	50.7	56.5	59.8	53.6	0.769	1.000	$612.52	$3,061.92
43	6	Retired	none	20.5	22.8	40.0	51.7	57.8	61.4	54.7	0.834	1.000	$612.52	$3,674.44
44	6	Retired	none	20.8	23.3	40.7	52.7	59.2	63.0	56.0	0.907	1.000	$612.52	$4,286.96
45	6	Retired	none	21.2	23.7	41.4	53.7	60.7	64.7	57.2	0.990	1.000	$612.52	$4,899.48
46	6	Retired	none	21.7	24.2	42.1	54.8	62.2	66.4	58.5	1.000	1.000	$612.52	$5,512.01
47	6	Retired	none	22.1	24.7	42.9	56.0	63.8	68.2	59.9	1.000	1.000	$612.52	$6,124.53
48	6	Retired	none	22.5	25.2	43.6	57.2	65.4	70.1	61.3	1.000	1.000	$612.52	$6,737.05
49	6	Retired	none	23.0	25.7	44.4	58.4	67.1	72.0	62.8	1.000	1.000	$612.52	$7,349.57
50	6	Retired	none	23.5	26.2	45.3	59.6	68.9	74.0	64.3	1.000	1.000	$612.52	$7,962.09
51	6	Retired	none	23.9	26.7	46.1	60.9	70.7	76.1	65.8	1.000	1.000	$612.52	$8,574.61
52	6	Retired	none	24.4	27.3	47.0	62.3	72.5	78.2	67.4	1.000	1.000	$612.52	$9,187.14
53	6	Retired	none	25.0	27.9	47.9	63.6	74.4	80.4	69.0	1.000	1.000	$612.52	$9,799.66
54	6	Retired	none	25.5	28.5	48.8	65.1	76.4	82.6	70.7	1.000	1.000	$612.52	$10,412.18
55	6	Retired	none	26.0	29.1	49.8	66.5	78.4	84.9	72.5	1.000	1.000	$612.52	$11,024.70
56	6	Retired	none	26.6	29.7	50.7	68.0	80.5	87.3	74.3	1.000	1.000	$612.52	$11,637.22
57	6	Retired	none	27.2	30.4	51.7	69.5	82.6	89.7	76.1	1.000	1.000	$612.52	$12,249.75

Table 8.7 Veteran Age 58 to 77 Hearing Threshold Level Aging and Noise and VA Medical Cost Estimates for the 0.005 Fractile of Susceptibility

Age	Yrs in noise	Event	Noise	Hearing threshold level, aging and noise						Max avg HL adjacent in 1 to 4 kHz	VA prob of HA for year	VA cum prob of HA	VA cost of HA for year ($440.03 avg plus overhead)	VA medical cumulative
				0.5 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz					
58	6	Retired	none	27.8	31.1	52.8	71.1	84.8	92.2	76.1	1.000	1.000	$612.52	$12,862.27
59	6	Retired	none	28.4	31.7	53.8	72.7	87.1	94.8	78.0	1.000	1.000	$612.52	$13,474.79
60	6	Retired	none	29.0	32.4	54.9	74.4	89.4	97.4	79.9	1.000	1.000	$612.52	$14,087.31
61	6	Retired	none	29.7	33.2	56.0	76.1	91.7	100.1	81.9	1.000	1.000	$612.52	$14,699.83
62	6	Retired	none	30.3	33.9	57.2	77.8	94.1	102.9	83.9	1.000	1.000	$612.52	$15,312.35
63	6	Retired	none	31.0	34.6	58.3	79.6	96.6	105.7	86.0	1.000	1.000	$612.52	$15,924.88
64	6	Retired	none	31.7	35.4	59.5	81.4	99.1	108.6	88.1	1.000	1.000	$612.52	$16,537.40
65	6	Retired	none	32.4	36.2	60.7	83.3	101.7	110.0	90.3	1.000	1.000	$612.52	$17,149.92
66	6	Retired	none	33.1	37.0	62.0	85.2	104.3	110.0	92.5	1.000	1.000	$612.52	$17,762.44
67	6	Retired	none	33.8	37.8	63.2	87.1	107.0	110.0	94.8	1.000	1.000	$612.52	$18,374.96
68	6	Retired	none	34.5	38.7	64.5	89.1	109.8	110.0	97.1	1.000	1.000	$612.52	$18,987.48
69	6	Retired	none	35.3	39.5	65.8	91.1	110.0	110.0	99.4	1.000	1.000	$612.52	$19,600.01
70	6	Retired	none	36.1	40.4	67.2	93.1	110.0	110.0	100.5	1.000	1.000	$612.52	$20,212.53
71	6	Retired	none	36.9	41.3	68.6	95.2	110.0	110.0	101.6	1.000	1.000	$612.52	$20,825.05
72	6	Retired	none	37.7	42.2	70.0	97.4	110.0	110.0	102.6	1.000	1.000	$612.52	$21,437.57
73	6	Retired	none	38.5	43.1	71.4	99.6	110.0	110.0	103.7	1.000	1.000	$612.52	$22,050.09
74	6	Retired	none	39.3	44.0	72.8	101.8	110.0	110.0	104.8	1.000	1.000	$612.52	$22,662.62
75	6	Retired	none	40.2	45.0	74.3	104.0	110.0	110.0	105.9	1.000	1.000	$612.52	$23,275.14
76	6	Retired	none	41.0	45.9	75.8	106.3	110.0	110.0	107.0	1.000	1.000	$612.52	$23,887.66
77	6	Dies	none	41.9	46.9	77.3	108.6	110.0	110.0	108.2	1.000	1.000	$612.52	$24,500.18

Table 8.8 Veteran Age 38 to 57 VA Compensation Cost Estimates for the 0.005 Fractile of Susceptibility

1	2	3	4	5	6	7	8	9	10	11	12	13
Age	Av HTLAN .5, 1, 2, 3 kHz	Max HTLAN .5, 1, 2, 3, 4kHz>40	3rd largest HTLAN of .5, 1, 2, 3, 4kHz>26	Exceeds VA criteria fence	Average HTLAN of 1, 2, 3, 4 kHz	VA roman numeral desig	% VA dis-ability	Monthly VA comp, $	% offset	Net monthly VA compensation cost, $	Total Navy and VA per year cost	Total Navy and VA cumulative cost
38	31.0	51.6	37.1	yes	39.2	I	0	$0.00	15	$0.00	$722.08	$7,848.19
39	31.5	52.7	37.6	yes	39.9	I	0	$0.00	15	$0.00	$612.35	$8,460.54
40	32.0	53.9	38.2	yes	40.7	I	0	$0.00	15	$0.00	$612.46	$9,073.00
41	32.6	55.2	38.8	yes	41.4	I	0	$0.00	15	$0.00	$612.51	$9,685.51
42	33.2	56.5	39.4	yes	42.2	II	0	$0.00	15	$0.00	$612.52	$10,298.02
43	33.8	57.8	40.0	yes	43.1	II	0	$0.00	15	$0.00	$612.52	$10,910.55
44	34.4	59.2	40.7	yes	44.0	II	0	$0.00	15	$0.00	$612.52	$11,523.07
45	35.0	60.7	41.4	yes	44.9	II	0	$0.00	15	$0.00	$612.52	$12,135.59
46	35.7	62.2	42.1	yes	45.8	II	0	$0.00	15	$0.00	$612.52	$12,748.11
47	36.4	63.8	42.9	yes	46.8	II	0	$0.00	15	$0.00	$612.52	$13,360.63
48	37.1	65.4	43.6	yes	47.8	II	0	$0.00	15	$0.00	$612.52	$13,973.15
49	37.9	67.1	44.4	yes	48.9	III	0	$0.00	15	$0.00	$612.52	$14,585.68
50	38.6	68.9	45.3	yes	50.0	III	0	$0.00	15	$0.00	$612.52	$15,198.20
51	39.4	70.7	46.1	yes	51.1	III	0	$0.00	15	$0.00	$612.52	$15,810.72
52	40.3	72.5	47.0	yes	52.3	III	0	$0.00	15	$0.00	$612.52	$16,423.24
53	41.1	74.4	47.9	yes	53.5	III	0	$0.00	15	$0.00	$612.52	$17,035.76
54	42.0	76.4	48.8	yes	54.7	III	0	$0.00	15	$0.00	$612.52	$17,648.29
55	42.9	78.4	49.8	yes	56.0	IV	10	$108.00	15	$16.86	$814.89	$18,463.18
56	43.8	80.5	50.7	yes	57.3	IV	10	$108.00	15	$16.86	$814.89	$19,278.07
57	44.7	82.6	51.7	yes	58.6	IV	10	$108.00	15	$16.86	$814.89	$20,092.96

Table 8.9. Veteran Age 58 to 77 VA Compensation Cost Estimates for the 0.005 Fractile of Susceptibility

1	2	3	4	5	6	7	8	9	10	11	12	13
Age	Av HTLAN .5, 1, 2, 3 kHz	Max HTLAN .5, 1, 2, 3, 4kHz>40	3rd largest HTLAN of .5, 1, 2, 3, 4kHz>26	Exceeds VA criteria fence	Average HTLAN of 1, 2, 3, 4kHz	VA roman numeral desig	% VA disability	Monthly VA comp, $	% offset	Net monthly VA pension cost, $	Total Navy and VA per year cost	Total Navy and VA cumulative cost
58	45.7	84.8	52.8	yes	59.9	IV	10	$108.00	15	$16.86	$814.89	$20,907.85
59	46.7	87.1	53.8	yes	61.4	IV	10	$108.00	15	$16.86	$814.89	$21,722.75
60	47.7	89.4	54.9	yes	62.8	V	20	$210.00	15	$32.79	$1,006.02	$22,728.77
61	48.7	91.7	56.0	yes	64.3	V	20	$210.00	15	$32.79	$1,006.02	$23,734.79
62	49.8	94.1	57.2	yes	65.8	V	20	$210.00	15	$32.79	$1,006.02	$24,740.81
63	50.9	96.6	58.3	yes	67.3	V	20	$210.00	15	$32.79	$1,006.02	$25,746.83
64	52.0	99.1	59.5	yes	68.9	V	20	$210.00	15	$32.79	$1,006.02	$26,752.84
65	53.1	101.7	60.7	yes	70.5	VI	30	$389.00	15	$60.74	$1,341.43	$28,094.27
66	54.3	104.3	62.0	yes	72.1	VI	30	$389.00	15	$60.74	$1,341.43	$29,435.70
67	55.5	107.0	63.2	yes	73.8	VI	30	$389.00	15	$60.74	$1,341.43	$30,777.13
68	56.7	109.8	64.5	yes	75.5	VI	30	$389.00	15	$60.74	$1,341.43	$32,118.56
69	57.9	112.6	65.8	yes	76.6	VII	40	$553.00	15	$86.35	$1,648.73	$33,767.30
70	59.2	115.4	67.2	yes	77.7	VII	40	$553.00	15	$86.35	$1,648.73	$35,416.03
71	60.5	118.3	68.6	yes	78.8	VII	40	$553.00	15	$86.35	$1,648.73	$37,064.76
72	61.8	121.3	70.0	yes	79.9	VII	40	$553.00	15	$86.35	$1,648.73	$38,713.50
73	63.1	124.3	71.4	yes	81.0	VII	40	$553.00	15	$86.35	$1,648.73	$40,362.23
74	64.5	127.4	72.8	yes	82.2	VII	40	$553.00	15	$86.35	$1,648.73	$42,010.96
75	65.9	130.5	74.3	yes	83.3	VII	40	$553.00	15	$86.35	$1,648.73	$43,659.70
76	67.3	133.7	75.8	yes	84.5	VIII	50	$772.00	100	$803.65	$10,256.35	$53,916.04
77	68.7	137.0	77.3	yes	85.7	VIII	50	$772.00	100	$803.65	$10,256.35	$64,172.39

g. Total costs for the nominal example.

(1) The estimate for the overall expected value of the total economic cost for the nominal example is shown on table 8.10. The expected value of the noise-related Navy and VA costs for the example sailor is $13,409.62. The progression over years after enlistment of the expected values for the various cost classes is plotted in figure 4.

Table 8.10. Expected Value Summation, Total Economic Cost of Exposing a Sailor to Noise, Nominal Case

Center probability (fractile)	Probability band width (fractile)	Cumulative probability (fractile)	Total cumulative cost for fractile	Expected value of total cost for probability band	STS in service, yes/no
0.005	0.01	0.01	$64,172.39	$641.72	yes
0.015	0.01	0.02	$41,423.87	$414.24	yes
0.025	0.01	0.03	$37,733.13	$377.33	yes
0.035	0.01	0.04	$35,331.29	$353.31	yes
0.045	0.01	0.05	$33,909.54	$339.10	yes
0.055	0.01	0.06	$32,306.63	$323.07	yes
0.065	0.01	0.07	$31,080.26	$310.80	yes
0.075	0.01	0.08	$29,848.00	$298.48	yes
0.085	0.01	0.09	$28,640.40	$286.40	yes
0.095	0.01	0.1	$28,126.33	$281.26	yes
0.110	0.02	0.12	$27,185.50	$543.71	yes
0.130	0.02	0.14	$26,173.06	$523.46	yes
0.150	0.02	0.16	$24,493.87	$489.88	yes
0.170	0.02	0.18	$23,624.80	$472.50	yes
0.190	0.02	0.2	$22,305.39	$446.11	yes
0.210	0.02	0.22	$21,463.62	$429.27	yes
0.230	0.02	0.24	$20,630.36	$412.61	yes
0.250	0.02	0.26	$20,006.48	$400.13	yes
0.270	0.02	0.28	$18,933.30	$378.67	yes
0.290	0.02	0.3	$18,321.59	$366.43	yes
0.310	0.02	0.32	$17,713.36	$354.27	yes
0.330	0.02	0.34	$17,107.79	$342.16	yes
0.350	0.02	0.36	$16,504.13	$330.08	yes
0.370	0.02	0.38	$15,901.71	$318.03	yes
0.390	0.02	0.4	$15,299.88	$306.00	yes
0.410	0.02	0.42	$14,698.03	$293.96	yes
0.430	0.02	0.44	$14,095.55	$281.91	yes
0.450	0.02	0.46	$13,491.86	$269.84	yes
0.470	0.02	0.48	$13,332.18	$266.64	yes
0.490	0.02	0.5	$12,723.86	$254.48	yes
0.510	0.02	0.52	$12,124.58	$242.49	yes
0.530	0.02	0.54	$11,534.81	$230.70	yes
0.550	0.02	0.56	$10,942.25	$218.85	yes
0.570	0.02	0.58	$10,346.35	$206.93	yes
0.590	0.02	0.6	$9,746.56	$194.93	yes
0.610	0.02	0.62	$9,142.43	$182.85	yes
0.630	0.02	0.64	$8,533.66	$170.67	yes
0.650	0.02	0.66	$7,920.32	$158.41	yes
0.670	0.02	0.68	$7,303.08	$146.06	yes

0.690	0.02	0.7	$1,724.67	$34.49	no
0.710	0.02	0.72	$1,724.67	$34.49	no
0.730	0.02	0.74	$1,724.67	$34.49	no
0.750	0.02	0.76	$1,724.67	$34.49	no
0.770	0.02	0.78	$1,724.67	$34.49	no
0.790	0.02	0.8	$1,724.67	$34.49	no
0.810	0.02	0.82	$1,724.67	$34.49	no
0.830	0.02	0.84	$1,724.67	$34.49	no
0.850	0.02	0.86	$1,724.67	$34.49	no
0.870	0.02	0.88	$1,724.67	$34.49	no
0.890	0.02	0.9	$1,724.67	$34.49	no
0.910	0.02	0.92	$1,724.67	$34.49	no
0.930	0.02	0.94	$1,724.67	$34.49	no
0.950	0.02	0.96	$1,724.67	$34.49	no
0.970	0.02	0.98	$1,724.67	$34.49	no
0.990	0.02	1	$1,724.67	$34.49	no
			Total expected value	$13,409.62	

(2) This total career cost is valid only for the sailor rotation schedules on which it is based. Other rotation schedules and VA criteria are discussed below.

h. Cost for early career reassignment because of hearing loss.

(1) This computation is an addendum to the costs associated with the nominal case example. It is included solely for illustration since the Navy practitioners indicate that disqualifying sailors out of their rating is too rare to be a significant cost. That is r(NOTwaived) is effectively 0.0.

(2) Information needed to estimate the added training cost caused by forced career changes because of hearing loss is summarized in table 6.1. The specific values are developed as follows:

(a) The disqualifying criteria (hearing acuity requirement) are suggested as: minimum HL of: 30 dB at 500, 1,000, and 2,000 Hz, 45 dB at 3,000 Hz, and 60 dB at 4,000 Hz.

(b) The training plan for this hypothetical example is listed in table 8.11. The costs are averages by course level from reference 8. The cost of basic training is not included because the sailor is reassigned and basic training is not lost.

Table 8.11. Training Plan and Costs for Hypothetical Example.

Course type	Level	Course duration, weeks	Cost per week	Training cost
Basic MM	A	6	$1,019.83	$6,119.00
Power School	C	26	$2,210.82	$57,481.32
Prototype	C	30.3	$2,210.82	$66,987.85
TRAIN$ (total cost of specialized training)				$130,588.16

(c) AVGTIME, the average time for the sailor in the MM career field is assumed to be 18 years for our example. The cost of training averaged over the normal 18 year career is $7,254.90

(d) The computation uses the same finite element approach as above. Within each probability increment and year, p(disqualify), the probability of exceeding the disqualifying criteria is either 1 or 0. PROFTIME is the actual year in which the disqualifying criteria are exceeded, and r(NOTwaived) is assumed to be 1.0.

(3) The computation of added training costs is summarized in table 8.12. The disqualifying criteria were exceeded only in the 0.005 and 0.015 fractiles which together comprise 2 % of the population.

(a) As shown on table 8.3, the criteria were exceeded in the 4th year after completion of training so that PROFTIME is 3.5 years for the 0.005 fractile. PROFTIME was 14.5 years for the 0.01 fractile. The expected value of the cost of additional training due to hearing loss is $1,378.11.

Table 8.12. Cost of Added Training Caused by Career Change Due to Hearing Loss.

Fractile	Probability band width	PROF TIME, years	Added cost of disqualifying	Expected value of added cost	Cumulative expected value of added cost
0.005	0.01	3.5	$105,171.85	$1,051.72	$1,051.72
0.015	0.01	13.5	$32,639.54	$326.40	$1,378.11
0.025	0.01	18	$0.00	$0.00	$1,378.11
Etc					$1,378.11

(b) The $1,378.11 is actually a slight underestimate of the added cost because the above calculation ignores second order costs effects. These second order effects arise because 2 % of the replacements for the disqualified MMs will also be disqualified out due to excessive hearing loss. In this case, the underestimate is less than about $20. If the disqualifying out occurred in a much larger percentage of the population then the underestimate could be more significant and these second order effects would be calculated.

i. Variations from the nominal example and indicated cost trends.

(1) The model can be used to estimate the sensitivity of the total cost to variations of input parameters and criteria. Table 8.13 shows the results. The results can be used to uncover some cost trends.

(2) The annualized cost per person-year is $1,117.49 for the nominal case. This is the total expected value per person divided by 12 years, the total time spent by the sailor assigned to the ship. For a total population of about 2300 of these specialized MMs, the total annual cost of the example noise exposure would be $2,570,227.

Table 8.13. Total Economic Cost of Exposing a Sailor to Noise for Variations from the Nominal Case

Item	Variation from nominal case	Total cost	Comment
1	None, nominal case for the example calculation	$13,409.62	12 years at sea, 6 years in noise, (6 months/year at sea), STS-based criteria, 95 dBA ambient level, 98 dBA TWA
2	12 years in noise	$15,731.47	12 months/year at sea instead of 6 months
3	3 years in noise	$10,841.31	3 months/year at sea instead of 6 months
4	No years in noise	$1,726.63	There is no STS, costs are only for the Navy HCP
5	+ 5dB noise levels	$18,459.70	Nominal case except with 100 dBA ambient level, 103 dBA TWA
6	Exit HL-based VA criteria	$4,574.23	VA costs based on only HL measured during service termination audiogram
7	All HL-based VA criteria	$13,784.71	VA costs based on HL irrespective of service connection
8	All HL-based VA criteria with no years at sea	$8,890.18	No NIHL, only aging
9	"Should cost" case for Navy HCP participation	$14,105.43	Same as nominal case except assumes 100% compliance with Navy HCP audiometric testing
10	Including VA tinnitus cost	$21,394.97	Nominal case except all VA costs were increased by a factor of 1.7
11	With added training costs	$14,787.73	Nominal case including added training costs using hypothetical hearing acuity criteria

(3) Items 2 through 5 show the sensitivity of the cost to variations in exposure duration and exposure level.

(a) Doubling and halving the exposure time has 15 to 20 % change in cost.

(b) Increasing the noise level by 5 dB, which the Navy considers more than doubling the noise hazard, increases the cost by about 36 %.

(c) These non-proportional cost consequences are indicative of a noise-related "cost overhead".

(4) Items 6 and 7 show the variation of cost with VA criteria for determining service-connection (see table 7.5).

(a) There is very little difference between the STS-based criteria and the all HL-based criteria. This is because STS is present for the costliest 68 % of the population.

(b) The VA's use of the "HL at exit" criteria would yield a significant cost reduction but this appears to be illegal.

(5) Item 8 is a hypothetical example. It shows the cost for a sailor improperly classed as noise exposed. The expected value is about 65% of that for item 7.

(a) This indicates that most of the cost of exposing a sailor to the nominal case environment is due to hearing loss associated with aging. The cost is incurred because of the principle of aggravation.

(b) This also appears to be the source of the noise-related "cost overhead" discussed above.

(6) Item 9 shows the costs incurred if participation in the Navy HCP audiometric testing was at 100% instead of the currently estimated 72%. The difference in total economic cost is small.

(7) Item 10 is an attempt to include the VA cost effects of tinnitus.

(a) Currently, the VA tinnitus costs are about 70% of VA hearing loss costs. Applying a 1.7 factor to VA hearing loss costs is somewhat speculative because the connection between steady noise (not impulse noise) exposure and tinnitus is not well established.

(b) The total annual cost of noise exposure for 2,324 sailors assigned to sea duty would be $4,143,492.30 if tinnitus were included in this manner.

j. Cost-related considerations not illustrated.

(1) The example calculates only the cost of that steady-state noise exposure sustained in the ship mechanical spaces during sea duty. It does not explicitly calculate cost of any impulse noise exposure. However, impulse noise effects may be implicitly included during the HL matching procedures undertaken in reference 2.

(2) The model only calculates those VA costs caused by the Navy steady-state noise exposure. This is implicitly equivalent to assuming that the veteran had no other noise exposure, either in the Navy or after retirement. Such an assumption would be untenable if it was made explicitly but it appears an unavoidable implicit part of the model. Part of the VA C&P examination is intended to determine if a claimed hearing loss was service-connected. If a veteran sailor's service record includes notation of exposure to high steady noise and an in-service STS then is appears unlikely that a VA claim based on subsequent HL could be denied. This is because of the principle of aggravation and the VA prohibition against age correction of HLs.

APPENDIX A

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APPENDIX B

Acknowledgement and Sources of Procedural Information

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APPENDIX C

ITEMS REQUIRING FURTHER RESEARCH FOR THE REFINED MODEL

Item no.	Description	Validation or refinement approach
1	CMAC costs by CPT code in the baseline model are for Baltimore	Use CMAC CPT costs geographically averaged over all localities
2	Compliance rate for military enrollees in the Navy HCP	Can be obtained from DOEHRS-HC data repository
3	Median HL for sailors entering the occupation	Can be obtained from DOEHRS-HC data repository
4	Probability of requiring hearing aids based solely on measured HLs	Can be obtained from a combination of DOEHRS-HC and CHCSII data repository
5	Various factors associated with estimating retraining costs due to disqualifying	Disqualify standards- search Navy regulations for hearing standards by rating Waiver rate- TBD Average length of service in specialty- Navy's Enlisted Master Records
6	VA costs of audiometric tests and HA	Request to VA
7	VA demographic data for beneficiaries including family size, beneficiary types, and life expectancy.	Request to VA
8	VA overhead costs	Request to VA
9	VA service-connectedness decision criteria for hearing loss	Request to VA

APPENDIX D

From: Dennis, Kyle,C [mailto:Kyle.Dennis@va.gov]
Sent: Tuesday, May 16, 2006 1:17 PM
To: Sachs, Felix Z Mr ORISE; Fausti, Stephen A. (Portland); Peterson, Eric; Leek, Marjorie (Portland); Campbell, John C (FAV); JRBealer@mar.med.navy.mil
Cc: marshall@nsmrl.navy.mil; Paul Weathersby
Subject: RE: Request for more help on VA decision criteria for service connectedness of hearing loss.

Based on the Institute of Medicine report, there is insufficient basis for delayed onset hearing loss and no compelling evidence based on animal models that hearing loss is not fully manifested within hours or days of exposure, assuming there is no further exposure. Nevertheless, there is evidence that a noise-damaged ear will not age the same as a non-damaged ear.

To be service connected, there must be evidence that the hearing loss was incurred in or aggravated by military service to a reasonable degree of medical certainty (generally taken to be at least as likely as not). Method 1 follows VA policy of awarding service connection (disability) for any such hearing loss regardless of when it was claimed. Therefore, VA disability tables do recognize the disabling effects of the **current** hearing loss, which may include contributing **non-service factors and aging**. Affirmative evidence of intervening factors such as occupational noise exposure or medical conditions are considered but do not in themselves rule out service connection if the basis of the claim is met (i.e. the hearing loss was incurred in or aggravated by service, whether or not it was disabling). There is no mechanism for offsetting liability as there is in worker compensation claims. Thresholds are not age adjusted. **The only basis for a successful claim is demonstration that all or some of the *current* hearing loss was incurred in or aggravated by military service to a reasonable degree of medical certainty.**

I modified the table as follows. The basis for SC differs in each method. The basis for disability (current hearing loss) is the same in all methods. Therefore, all models compensate non-service factors and aging once the basis for service connection is proven.

Method 1 incorporates current regulations. As regulations are not likely to change, this method is most predictive of the costs of compensating hearing loss.

Method 2 assumes that all hearing loss after separation is not service-related and recognizes the IOM conclusion that hearing loss incurred after separation (actually within one year of separation) is probably not service related. Service connection is strongly based on this fact, but once determined that service connection exists, the **current** hearing loss is the basis for disability. However, this model assumes that all service members receive a separation audiogram. The separation audiogram only provides affirmative evidence that disabling hearing loss did not occur in service; it does not protect the Government against a claim that hearing *changed* during military service or was *aggravated* by military service (i.e. aggravated a pre-existing hearing loss). Only induction and separation audiograms provide such risk avoidance.

Method 3 assumes the ideal (and recommended) situation where service members have induction and exit audiograms. A pair of induction and separation audiograms (preferably with intervening hearing conservation monitoring) provides an objective basis for rebutting service connection. There are limited instances where there is evidence of STS but hearing at discharge is normal. Such cases can be adjudicated in favor of the veteran only when there is affirmative evidence that the changes in hearing were related to military service (e.g. noise exposure, combat).This is prudent risk management. In fact, IOM showed that relatively few service members had both induction and separation audiograms, although most had at least one audiogram. Failure to provide induction and separation audiograms make it virtually impossible to assign service connection with certainty.

Method 4 assumes that service-connection occurs only when STS is demonstrated and recognizes that STS is strong indicator of noise exposure. Nevertheless, STS cannot be the sole basis for establishing

service connection because not all veterans were monitored in hearing conservation programs or received induction/separation audiograms and not all hearing loss is due to noise. Hearing loss due to intervening medical conditions may be service connected unless the medical condition is itself a ratable condition. An STS might be due to other reasons (e.g. recreational noise, medical conditions). Follow-up would have to affirm the presence of STS and determine a cause. Many service members are lost to follow-up.

Methods 2-4 are probably mathematically easier to model. Most claims are adjudicated one way or the other on the basis of objective findings such as audiograms, at least for periods of service after 1970. Only when audiograms are not present or evidence is conflicting are audiologists asked to provide opinions. This can be difficult to model because opinions are often based on military records, written notes, scientific evidence, and inference. Model 3 could show how a comprehensive hearing loss monitoring program could avoid the costs of compensation.

Presumption was a formula considered by Congress for addressing the high costs of adjudicating hearing loss claims. Congress ordered VA to fund the IOM study. While presumption was clearly the basis for Congress' interest, IOM was not specifically tasked with addressing presumption. Presumption means that a condition is definitively or strongly associated with military service and is presumed to be related to service if certain conditions are met. Typically, presumptive conditions are related to certain periods of service, certain military experiences, or known hazard exposures. If Congress at some point determines that hearing loss is presumptive, the issue would not be causality but rather degree of current disability. Exactly how presumption would be assigned remains problematic.

Type	Basis for SC	Basis for Disability	Possible rationale	Pros and cons
1. All HL-based	Incurred in or aggravated service	Current hearing loss	Hearing loss must be shown to be incurred in aggravated by service, unless rebutted by evidence of misconduct	Pro- consistent with Federal regulations Con- can be subjective when objective evidence is not present in the record. May compensate non-service and ARHL.
2. Exit HL-based	HLs on exit audiogram	Current hearing loss	All HL after separation and for a period of one year after separation is presumed to be age-related and/or produced by non-service factors	Pro- affirmative, objective evidence of hearing loss at separation Con- assumes that service members have exit audiograms. Does not protect against claims of changes in hearing or aggravation of pre-existing HL.
3. Induction/Exit HL-based	HLs on induction and exit audiograms	Current hearing loss	All HL after separation and for a period of one year after separation is presumed to be age-related and/or produced by non-service factors	Pro- affirmative, objective evidence of service-related hearing loss Con- assumes that service members have induction and separation audiograms
4. STS-based	Only if sailor had an STS during active duty	Current hearing loss	Use the STS record as objective evidence of NIHL sustained in service	Pro- attempts to objectively identify NIHL based on in-service audiogram records Con- STS values are somewhat arbitrary. Assumes that STS is related to noise and is duty related. Denies other causes of hearing loss. Assumes that identified service members are followed up.

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From: Dennis, Kyle,C [mailto:Kyle.Dennis@va.gov]
Sent: Tuesday, May 17, 2006
To: Sachs, Felix Z Mr ORISE; Fausti, Stephen A. (Portland); Peterson, Eric; Leek, Marjorie (Portland); Campbell, John C (FAV); JRBealer@mar.med.navy.mil
Cc: marshall@nsmrl.navy.mil; Paul Weathersby
Subject: RE: Request for more help on VA decision criteria for service connectedness of hearing loss.

VA disability only requires that there be reasonable evidence that hearing loss was incurred in or aggravated by military service (Method 1). Requiring affirmative evidence of hearing loss by STS or exit audiogram, while compelling audiologically, is not the basis for a successful claim. A veteran could have had STS and not have hearing loss at separation. PTS would most likely be confirmed at separation and is probably the more powerful metric. Nevertheless, in the absence other evidence, STS could be given significant weight in a claim, especially if the service member had been enrolled in HCP. A hearing loss at separation (without entrance audiogram) does not take into account the status of hearing at induction. Again, in the absence of other evidence, a hearing loss at separation alone could be the basis for a successful claim. Using the "reasonable person" standard, it would be difficult to opine otherwise.

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APPENDIX E.

Figures

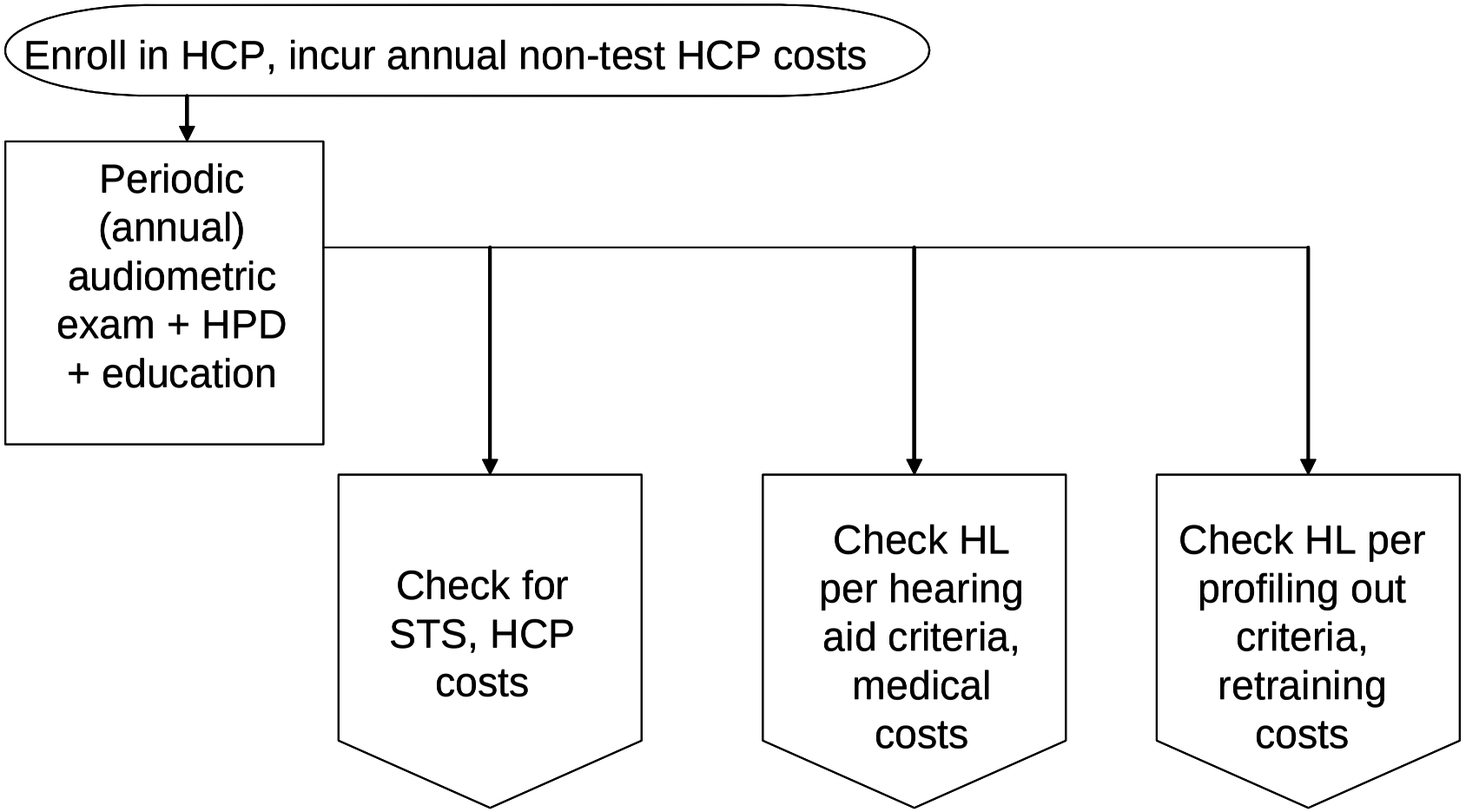

Figure 1. Diagram of Procedure for Annual Monitoring Audiometry in the Navy Hearing Conservation Program, Part 1,

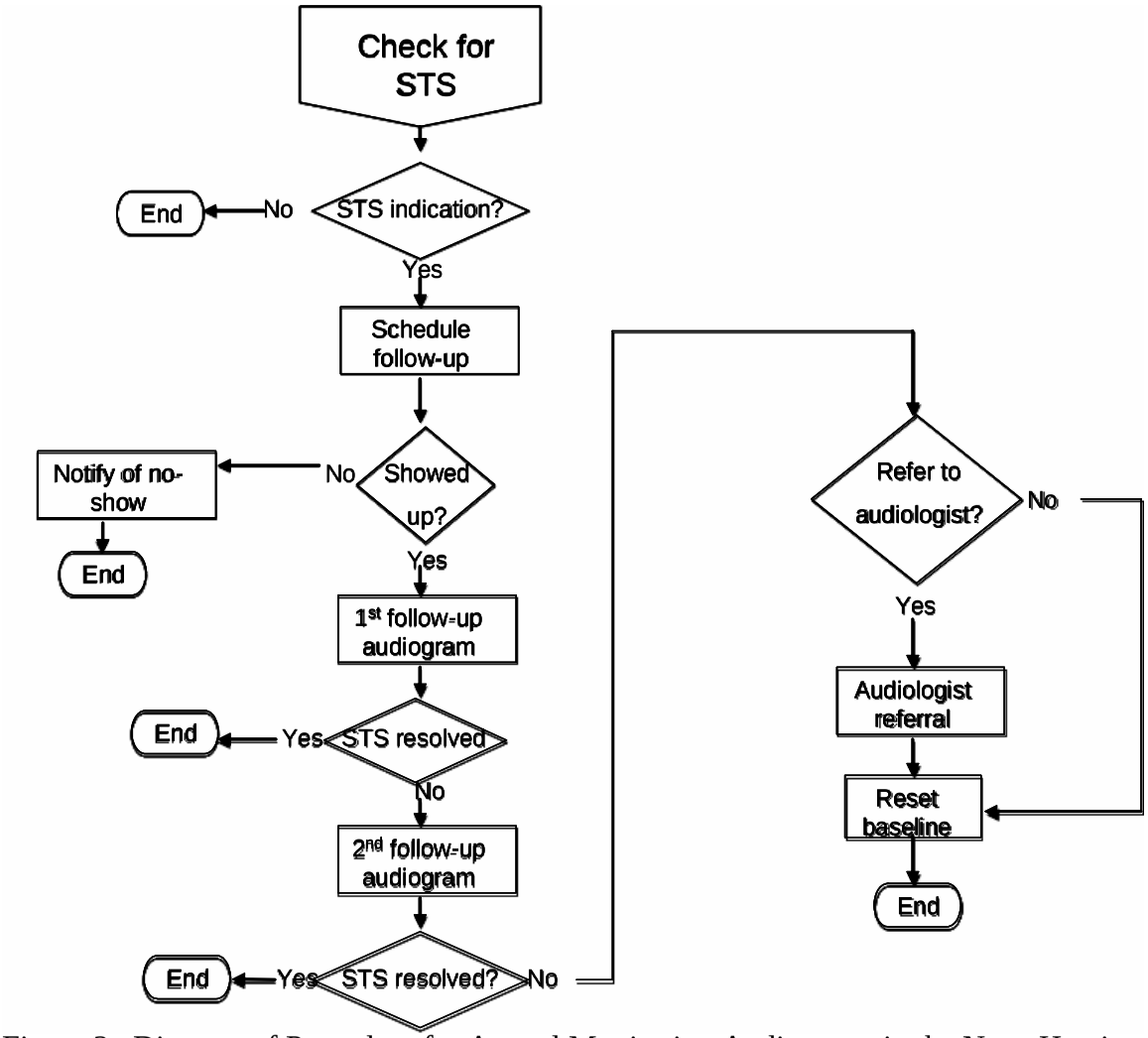

Figure 2. Diagram of Procedure for Annual Monitoring Audiometry in the Navy Hearing Conservation Program, Part 2

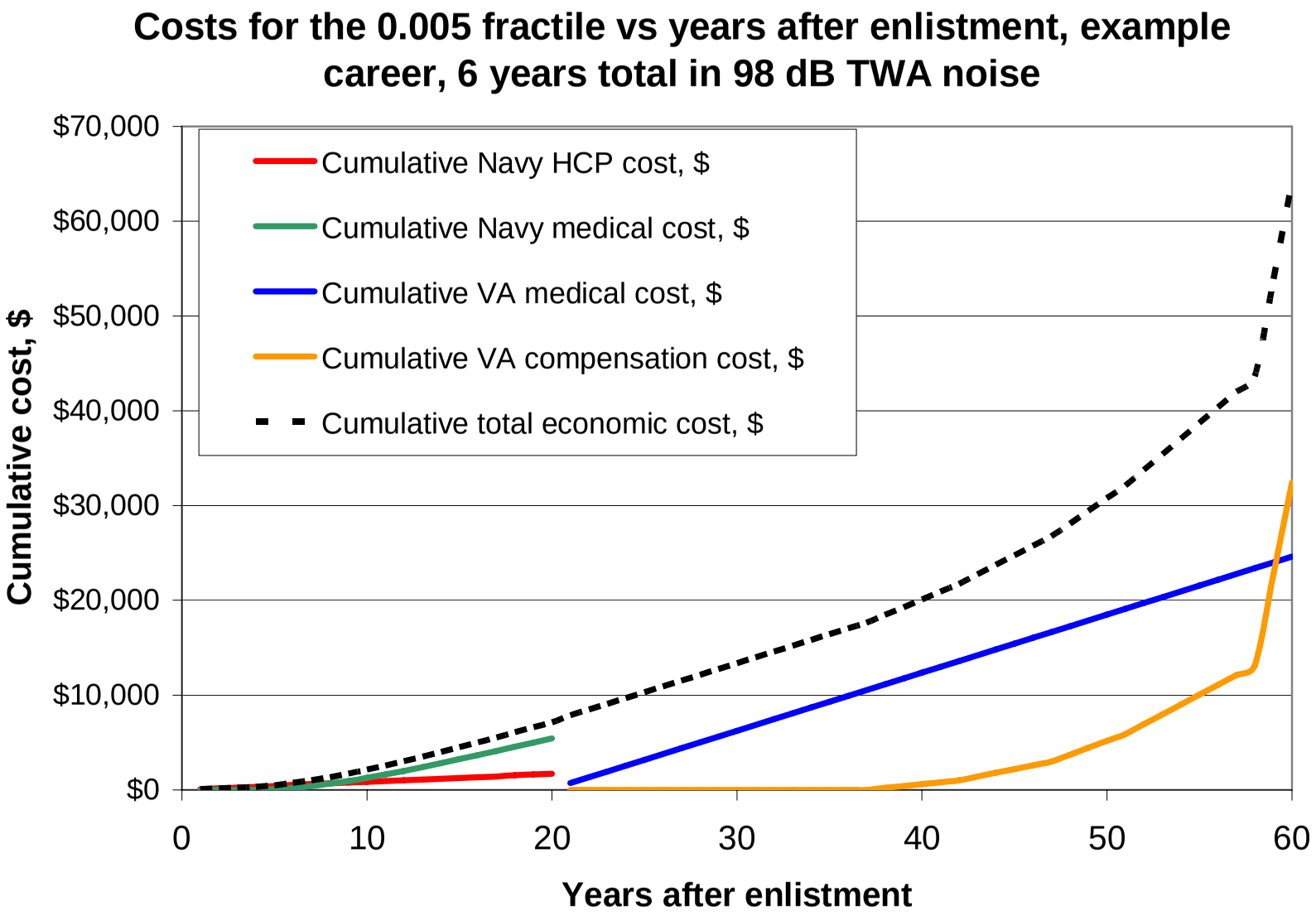

Figure 3. Cumulative Cost vs Years after Enlistment for the 0.005 Fractile Susceptible Sailor.

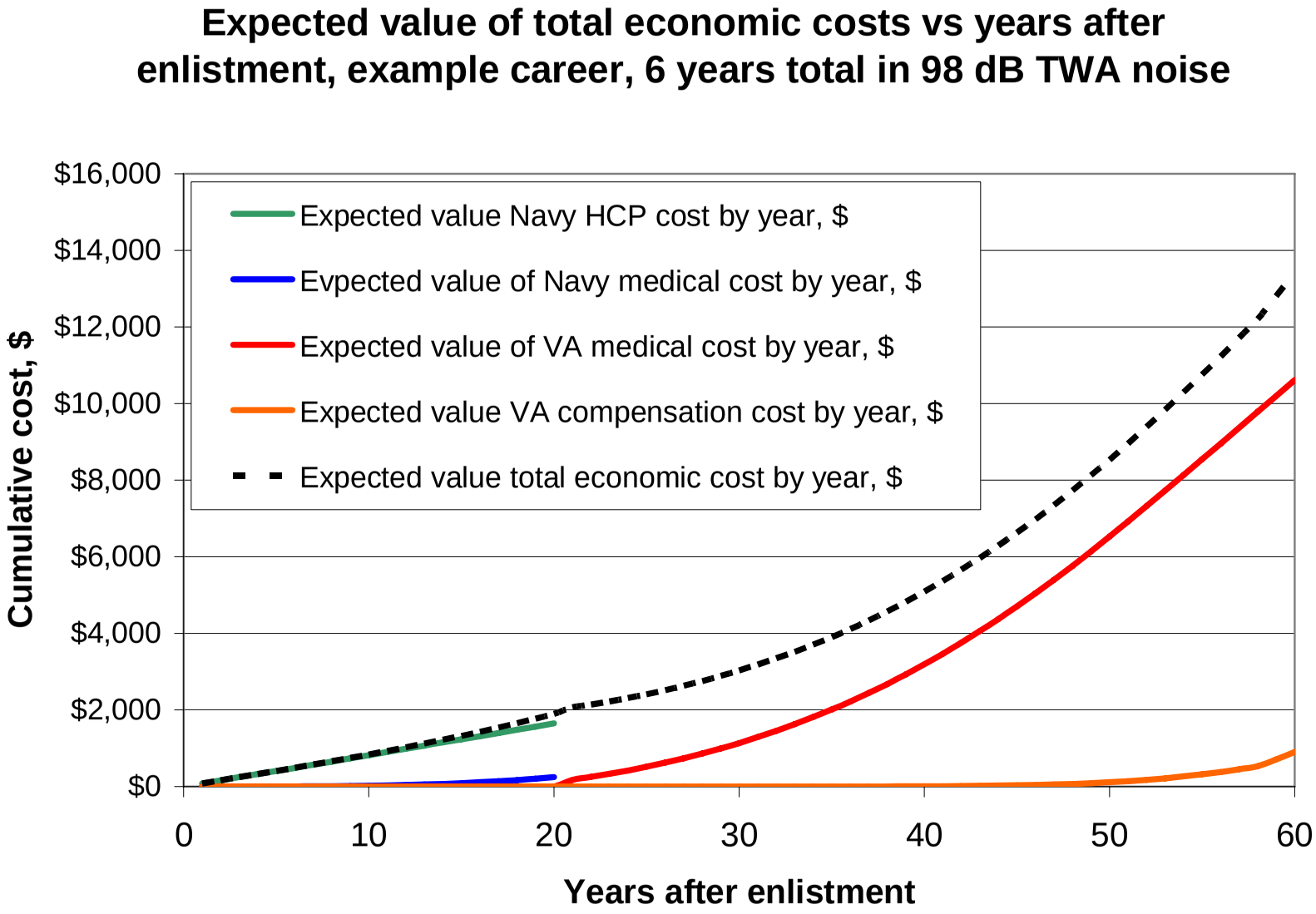

Figure 4. Total Expected Value of Cost vs Years after Enlistment.

GLOSSARY

ANSI- American National Standards Institute

AVGTIME- average time period a sailor work in a specialty before leaving for some reason other than disqualifying

baseline audiogram- the sailor's audiogram used as the reference in detecting a significant threshold shift (STS) in subsequent audiograms (not related to baseline model)

baseline model- the version of cost algorithm developed as a result of the effort documented in this report (not related to baseline audiogram). By contrast, the refined model is expected to be developed during follow-on efforts.

CHCS- Composite Health Care System

CMAC- CHAMPUS maximum allowable charge

CPT- current procedural terminology

DoD- Department of Defense

DOEHRS-HC- Defense Occupational and Environmental Health Readiness System – Hearing Conservation

DR- DOEHRS data repository

ENT- ear nose and throat physician

f/u- follow-up audiometric test

HA- Hearing aid
HCP- Navy hearing conservation program

HL- hearing level, usually as measured on an audiometer (includes aging and noise induced permanent threshold shift and possibly temporary threshold shift)

HPD- Hearing protective device

HTLA- Hearing threshold level from aging only

HTLAN- Hearing threshold level from aging and noise

kHz- kilohertz

MEPRS- Medical expense and performance reporting system

NEC- Navy enlisted classification

NIHL- Noise-induced hearing loss

OA- Overhead cost

PEHI- percentage evaluations for haring impairment (see VA Audiology handbook)

p(HArefer)- Probability of exceeding HA criteria

p(realSTS)- Probability of a real (unresolvable) STS

PROFTIME - sailor's time in the specialized occupation before being disqualified out for hearing loss

PTS- permanent threshold shift

r(AudiologistConsult)- Rate of audiologist consult for unresolved STS

r(comp)- Rate of compliance with annual audiometry

r(falseSTS)- Rate of false positive STS in periodic audiogram

r(funoshow)- Rate of no-shows for first follow-up (f/u 1) audiogram

r(furepeat)- Rate of need for repeat follow-up audiogram

r(HAissue)- Rate of issuing HA

STS- Significant threshold shift. Currently defined as a change in hearing of an average of ± 10 dB at 2000, 3000 and 4000 Hz in either ear, relative to the current reference audiogram. The STS criteria previously also included any change of ± 15 dB at 1000, 2000, 3000 or 4000 Hz in either ear but this portion of the STS criteria was eliminated

TBD- to be defined

Time-intensity exchange rate- The change in the level of sound required to double the damage potential of the sound during a fixed time period of exposure. This exchange rate is implicit in the TWA.

TRAIN$- The cost of training a sailor for a specialty

TTS- Temporary threshold shift

TWA- 8-hour time weighted average noise level using a specified exchange rate. For Navy hearing conservation purposes, the exchange rate is 4 dB. For ANSI S3.44, the exchange rate is 3 dB. If the exchange rate is 3 dB the TWA is equivalent to L_{A8hr}

VA- Department of Veterans Affairs

USACHPPM- U.S. Army Center for Health Promotion and Preventive Medicine